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Standards of Performance for the control of VOC emissions from magnetic tape coating lines are being proposed under the authority of Section 111 of the Clean Air Act. These standards would apply to all new, modified, and reconstructed magnetic tape coating lines using at least 38 cubic meters of solvent per year in the production of magnetic tape. This document contains background information and environmental and economic impact assessments of the regulatory alternatives considered in developing the proposed standards.

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December 1985

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ENVIRONMENTAL PROTECTION AGENCY

Background Information
and Draft
Environmental Impact Statement
for the Magnetic Tape Manufacturing Industry

Prepared by:

Jack R. Farmer 12/17/85

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1. The proposed standards of performance would limit emissions of volatile organic compounds (VOC's) from new, modified, and reconstructed facilities that manufacture magnetic tape. Section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary source of air pollution that ". . . causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

2. Copies of this document have been sent to the following Federal Departments: Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, and Interior; the National Science Foundation; the Council on Environmental Quality; State and Territorial Air Pollution Program Administrators; EPA Regional Administrators; Association of Local Air Pollution Control Officials; Office of Management and Budget; and other interested parties.

3. The comment period for review of this document is 75 days from the date of publication of the proposed standard in the Federal Register. Mr. Gilbert H. Wood may be contacted at (919) 541-5578 regarding the date of the comment period.

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1. SUMMARY

1.1 REGULATORY ALTERNATIVES

This background information document (BID) supports proposal of the new source performance standards for limiting emissions of volatile organic compounds (VOC) from the magnetic tape coating industry. The development of standards of performance for new, modified, or reconstructed stationary sources of air pollution were dictated by Section 111 of the Clean Air Act (42 USC 7411). The sources of the VOC emissions are the solvent storage tanks, coating mix preparation equipment, and coating operation. The regulatory alternatives considered are presented in Chapter 6. Regulatory Alternatives I and IV represent the baselines, the levels of control that would be experienced in the absence of an NSPS, for plants located in ozone attainment and nonattainment areas, respectively. The remaining alternatives represent additional control of emissions from the solvent storage tanks, coating mix equipment, and coating operation in the magnetic tape coating process.

Alternative I represents uncontrolled solvent storage tanks, mix preparation equipment, and coating operations in magnetic tape coating plants and is the level of control presently required of plants located in ozone attainment areas. Alternative IV represents an overall control level of 75 percent of the total emissions from the line and corresponds to the Control Techniques Guideline (CTG) requirement of 0.35 kg of VOC per liter of coating (2.9 lb VOC per gallon of coating) for existing paper coating facilities and is based on application of reasonably available control technology (RACT) to magnetic tape coating processes. The 75 percent control level of Alternative IV can be achieved by capturing all drying oven emissions and by venting all of these emissions to a control device that achieves 95 percent VOC control.

Alternatives II and III represent control levels achievable from control of storage tanks and mix room equipment only. Alternative II represents the estimated control level achievable by venting each storage tank to the atmosphere through conservation vents and by placing sealed covers on the individual pieces of equipment in the mix room and venting the emissions from each of these to the atmosphere through conservation vents. This represents an overall control level of 4 percent of the total emissions from the line. The level of control represented by Alternative III is achievable by installing conservation vents on the storage tanks and by placing domed covers on the individual mix equipment and venting the emissions to a control device that is 95 percent efficient.

This results in a 9 percent line control efficiency. The option of controlling solvent storage tank emissions by venting the tanks to a control device was not evaluated in conjunction with the other emission sources because of the high costs that would be associated with installation of this system.

Regulatory Alternatives V, VIII, and X are based on control of only the solvent storage tanks with conservation vents and control of the coating operation (application/flashoff area and drying oven). Alternative V is based on an overall VOC reduction of 78 percent. The control system for this alternative can be achieved by capturing approximately 95 percent of all VOC emissions from the coating operation and by venting all of these emissions through a control device that achieves a 95 percent control efficiency. Alternatives VIII and X are based on essentially complete capture of all emissions from the coating operation and control of these emissions by a 95 and 98 percent efficient control device, respectively. This results in an 83 percent control level for Alternative VIII and a 85 percent control level for Alternative X.

Regulatory Alternatives VI, VII, IX, and XIA through XIV represent various combinations of control levels achievable by control of solvent storage tanks and of both the mix room equipment and the coating operation. The control levels are the sum of the control levels for the respective combinations of Alternatives II and III with IV, V, VIII, and X.

1.2 ENVIRONMENTAL IMPACT

The primary environmental pollutant from the magnetic tape coating industry is the emission of VOC from the solvent storage tanks, mix preparation equipment, and coating operation. Emissions of VOC can potentially cause an air pollution problem because they are precursors to the formation of ozone and oxygenated organic aerosols (photochemical smog).

An overview of the potential environmental impacts that could result from the implementation of the regulatory alternatives is presented in Table 1-1. The impacts summarized in Table 1-1 are for fixed-bed carbon adsorbers, the most common control device in the magnetic tape coating industry. The impacts for other control devices are presented in Chapters 7 and 8 and Appendix E. The estimated effects shown in this table are based on comparisons between the regulatory alternatives and baseline. For Regulatory Alternatives II and III, baseline is Alternative I. For Regulatory Alternatives V through XIV, baseline is Alternative IV. The impacts represent changes above or below the baseline regulatory alternative. Detailed analyses of the environmental and energy impacts associated with each alternative are discussed in Chapter 7.

Nationwide VOC emissions from new, modified, or reconstructed magnetic tape coating lines were estimated for the years 1985 to 1990. It is projected that 21 new magnetic tape coating lines will be constructed by 1990. Under Regulatory Alternative I, in 1990, emissions from new lines

TABLE 1-1. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF REGULATORY ALTERNATIVES[a,b]

Administrative action	Air impact (**)	Water impact[b] (*)	Solid waste impact[b] (*)	Energy impact (***)	Noise impact (-)	Economic impact (*)
Alternative I 0 percent control	0	0	0	0	0	0
Alternative II 4 percent control	+1	0	0	0	0	+1
Alternative III 9 percent control	+2	0	-1	-2	0	-1
Alternative IV 75 percent control	0	0	0	0	0	0
Alternative V 78 percent control	+1	-1	-1	-1	0	+1
Alternative VI 79 percent control	+1	0	0	0	0	+1
Alternative VII 82 percent control	+2	-1	-1	-1	0	+1
Alternative VIII 83 percent control	+2	-1	-1	-2	0	+1
Alternative IX 84 percent control	+2	-1	-1	-2	0	+1
Alternative X 85 percent control	+2	0	+2	-4	0	-4
Alternative XIA 87 percent control	+2	-1	-1	-2	0	+2
Alternative XIB 87 percent control	+2	-1	-1	-2	0	+2
Alternative XII 89 percent control	+3	0	+2	-4	0	-3
Alternative XIII 93 percent control	+3	-1	-1	-2	0	+2

(continued)

TABLE 1-1. (continued)

Administrative action	Air impact (**)	Water impact[b] (*)	Solid waste impact[b] (*)	Energy impact (***)	Noise impact (-)	Economic impact (*)
Alternative XIV 94 percent control	+3	0	+1	-4	0	-4
Delayed standard	0	0	0	0	0	0

[a] Baseline is Alternative I for Alternatives II and III. Baseline is Alternative IV for Alternatives V through XIV.

[b] The impacts presented are for fixed-bed carbon adsorbers, the most common control device in the magnetic tape coating industry.

KEY

+Beneficial impact	0--No impact
-Adverse impact	1--Negligible impact
*Short-term impact	2--Small impact
**Long-term impact	3--Moderate impact
***Irreversible impact	4--Large impact

would reduce emissions from new lines to 2,040 Mg (2,250 tons) in 1990. The most stringent level of control, Alternative XIV, would reduce VOC emissions in 1990 to 480 Mg (540 tons). The incremental impact of Alternative XIV on the baseline control case (Alternative IV) would be to reduce nationwide VOC emissions from magnetic tape coating lines by an additional 76 percent in 1990.

Table 1-1 indicates that the regulatory alternatives are likely to cause negligible to moderate adverse impacts in terms of water quality and solid waste generation. The operation of fixed-bed carbon absorbers produces wastewater containing dissolved organics. There are no wastewater discharges from fluidized-bed carbon adsorbers, incinerators, or condensation systems. At most lines in this industry, the wastewater is currently discharged to publicly owned treatment works. Nationwide in 1990, the total quantity of wastewater produced under Alternative IV would be approximately 17 million liters (5 million gallons). The implementation of Regulatory Alternative XIII would cause the greatest increase in wastewater, 25 percent, compared to Alternative IV. The operation of fixed-bed and fluidized-bed carbon adsorbers generates some solid waste in the form of waste carbon. The total quantities of solid waste (fluidized-bed) generated on a national basis in the year 1990 under Alternative IV would be approximately 20 Mg (22 tons) and under Alternative XIII would be approximately 21 Mg (23 tons).

The VOC emission control equipment in the magnetic tape coating industry utilizes energy in the forms of electricity, natural gas, and fuel oil. The amount of energy required increases with increasing levels of VOC control. Under Regulatory Alternative IV, in 1990, new magnetic tape coating lines would require 119 terajoules (TJ) (113 billion Btu) of energy to operate VOC emission control devices. This is assuming that only carbon adsorbers are installed to recover solvent emissions. Regulatory Alternative XIV (incinerator) would require the largest amount of energy, 183 TJ (173 billion Btu).

The noise levels attributable to air pollution control equipment are not a significant problem in the magnetic tape coating industry. Motors and solvent laden air fans are responsible for the majority of the noise in VOC control systems. Only negligible increases in noise levels occur as a result of increasingly stricter regulatory alternatives.

1.3 ECONOMIC IMPACTS

The economic impacts of each regulatory alternative are presented in Table 1-1. Cumulative capital control costs over the first 5 years would be $19 million under Alternative XIII compared to $18 million for control under the baseline, Alternative IV. Fifth year annualized costs under Alternative XIII would amount to $85,600 compared with the annualized cost of $846,000 for the baseline alternative. This is assuming only fixed-bed carbon adsorbers are installed.

The economic analyses indicate that the worst-case maximum price impact is 1.03 percent for Regulatory Alternative XIV. The regulatory alternatives would have little or no impact on the industry's growth rate and structure. Detailed analyses of the costs and the economic impacts are presented in Chapters 8 and 9.

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by the EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by the EPA in the development of the proposed standards.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission limitation and the percentage reduction achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which commences after the standards are proposed in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance. Examples of the effects of the 1977 amendments are:

1. EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.

2. EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

3. The term "standards of performance" is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low- or nonpolluting process or operation.

4. The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements.

Congress had several reasons for including these requirements. First, standards having a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or by effectively excluding certain coals from the reserve base due to their high untreated pollution potentials. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improving technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or than those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to State limitations that are more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term "best available control technology" (BACT), as defined in the Act, means

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to Sections 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases, physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions (i.e., high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, under Section 111(j) the Administrator may, with the consent of the Governor of the State in which a source is to be located, grant a waiver of compliance to permit the source to use an innovative technological system or systems of continuous emission reduction. In order to grant the waiver, the Administrator must find that: (1) the proposed system has not been adequately demonstrated; (2) the proposed system will operate effectively and there is a substantial likelihood that the system will achieve greater emission reductions than the otherwise applicable standards require or at least an equivalent reduction at lower economic, energy, or nonair quality environmental cost; (3) the proposed system will not cause or contribute to an unreasonable risk to public health, welfare, or safety; and (4) the waiver when combined with other similar waivers, will not exceed the number necessary to achieve conditions (2) and (3) above. A waiver may have conditions attached to ensure the source will not prevent attainment of any NAAQS. Any such condition will be treated as a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards and a mandatory compliance schedule will be imposed.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Administrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of an approach for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these areas are pollutants that are emitted by stationary sources rather than the stationary sources themselves. Source categories that emit these pollutants were evaluated and ranked considering such factors as: (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might be required from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected using these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all source categories not yet listed by the EPA. These are: (1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases, it may not be immediately feasible to develop standards for a source category with a high priority. This might happen if a program of research is needed to develop control techniques or if techniques for sampling and measuring emissions require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process, the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from these facilities may vary according to magnitude and control cost. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by standards of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must: (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the nonair quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as to new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering; (2) analysis of the information; and (3) development of the standard of performance.

During the information gathering phase, industries are questioned through telephone surveys, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from other sources, including a literature search. Based on the information acquired about the industry, the EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

The EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several alternatives, the EPA selects the single most plausible regulatory alternative as the basis for standards of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into performance standards, which, in turn, are written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the background information document (BID). The BID, the proposed standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within the EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA assistant administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. The EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standard with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D.C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and the EPA's position on the issues raised are included in the "preamble" of a promulgation package, which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of: (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance; (2) the potential inflationary and recessionary effects of the regulation; (3) the effects the regulation might have on small business with respect to competition; (4) the effects of the regulation on consumer costs; and (5) the effects of the regulation on energy use. Section 317 requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is taken because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact of the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counterproductive environmental effects of proposed standards, as well as economic costs to the industry. On this basis, therefore, the Courts established a narrow exemption from NEPA for EPA determinations under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, the EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is included in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the General Provisions (40 CFR Part 60, Subpart A), which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of standards of performance requires States to establish standards of performance for existing sources in the same industry under Section 111(d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, the EPA must establish such standards. General procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every 4 years, review and, if appropriate, revise . . ." the standards. Revisions are made to ensure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE MAGNETIC TAPE MANUFACTURING INDUSTRY PROCESSES AND POLLUTANT EMISSIONS

3.1 GENERAL

This chapter describes the magnetic tape coating industry, the processes used in this industry, the sources of pollutant emissions, and the factors affecting emissions.

3.1.1 Industry Description

The magnetic tape coating industry is included in two Standard Industrial Classification (SIC) codes: 3679, "Electronic Components Not Elsewhere Classified," and 3573, "Electronic Computing Equipment." In the manufacturing process, a mixture of magnetic particles, resins, and solvents is coated on a thin plastic film. The emissions of concern are volatile organic compounds (VOC) that result primarily from the vaporization of solvents in the storage tanks, in the coating mix preparation area, in the coating application/flashoff area, and in the drying oven. The drying oven is the largest emission source.

Magnetic tape is used for audio and video recording and computer information storage. Other uses of magnetic tape include magnetic cards, credit cards, bank transfer ribbons, instrumentation tape, and dictation tape. Table 3-1 presents a summary of the physical parameters of products in the three major magnetic tape categories.

Table 3-2 presents the names and locations of the domestic plants that coat magnetic tape and the type of tape produced. There are 30 plants, representing 24 companies, in 15 States. Unlike many manufacturing processes, magnetic tape coating is not restricted to select regions of the country by raw material or market requirements. California, with 11 plants, has the largest population. Seventeen (56 percent) of the plants coat only one major type of product, eleven (37 percent) coat two major types, and two (7 percent) coat three major types. Each plant contains from one to seven coating lines.[1] Other related activities that may take place at these plants include audio tape prerecording, record production, and production of plastic cassette reels.

3.1.2 Industry Growth

The magnetic tape recording industry began in the late 1940's with reel-to-reel audio tape recorders. Commercial industrial development of video and computer tape began in the 1950's, and individual home use of these products has increased greatly since the mid-1970's.[2] Magnetic tape production from 1976 to 1981 is shown in Figure 3-1. In 1981, the total quantity of magnetic tape shipped was approximately 736,000,000 m^2 (~7,925,000,000 ft^2), of which 50 percent was audio tape, 31 percent was computer tape, and 19 percent was video and instrumentation tape.[3] For further details of the historical growth in this industry, see Section 9.1.

Of the three major magnetic tape categories, computer and video tape products are expected to experience the most rapid growth and audio tape products are expected to experience almost negligible growth.[3-5]. Flexible disk sales are expected to increase from 30 to 45 percent through 1990.[6-9] Two estimates of increased video tape production, based on consumption of plastic film, project an average annual growth of ~25 percent through the decade.[10,11]

3.2 PROCESSES AND THEIR EMISSIONS

3.2.1 Process Descriptions

The process for manufacturing magnetic tape consists of mixing the coating ingredients (including the solvents), conditioning the base film, applying the coating to the base film, orienting the magnetic particles, removing the solvents by evaporation in a drying oven, and finishing the tape by calendering, rewinding, slitting, testing, and packaging. The magnetic particles are bonded to the tape by a permanent coating. Solvents are added to the coating mix to reduce viscosity and increase flow properties, allowing the coating to be applied more uniformly. The solvents must subsequently be removed. In some cases, removal of the solvent causes the coating to harden; other coatings are chemically reactive and cure through polymerization of the resin oligomers. Figure 3-2 presents a schematic of a magnetic tape coating line. The VOC emissions are produced primarily during coating and drying of the tape and in lesser amounts during solvent storage, mix preparation, and cleaning of the equipment.

3.2.1.1 Raw Materials. Magnetic tape has two components, the magnetic coating and the base support or web to which this coating is applied. Several types of base films have been used, but polyester is the most common type currently used because it has the best combination of chemical and mechanical properties, availability, and cost.[12] Polyester film can be used with any magnetic tape coating formulation. The thickness of the base film varies with the product, ranging from 5.1 to 192 μm (0.20 to 7.50 mils).[1,12,13] The width of the film ranges from 7.6 to 122 cm (3 to 48 in.).

The exact composition of the coating may vary slightly with the desired end use of the magnetic tape and the desired quality of reproduction. However, the basic components (magnetic particles, binder, solvents) are the same for all types of tape. Table 3-3 presents coating composition ranges by both weight and volume.

Four types of magnetic particles are used in magnetic tape: γ-ferric oxides, doped iron oxides, chromium dioxide, and metallic particles that usually consist of elemental iron, cobalt, or nickel.[14] The magnetic particles normally make up about 10 to 39 percent (by weight) of the coating mix.[15,16]

The binder (resin or cross-linker) is an organic polymer that holds the magnetic material together in a flexible matrix that adheres to the base film. Most coating mixes contain thermoset binders, particularly polyurethanes and polyvinyls.[17] The coating mix normally contains about 2 to 20 percent (by weight) binder.[15,18]

Solvents are used to dissolve the binder polymers and to provide a fluid medium for the dispersion of particles in the coating mix.[19] The major solvents used in the coating mix are tetrahydrofuran (THF), methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), toluene, and cyclohexanone.[1] Various combinations of up to five of the solvents may be used.[1] Factors affecting solvent selection are toxicity, availability, cost, ease of solvent recovery after use, desired rate of evaporation, and effect on solvent recovery equipment.[19,20] The solvent in the coating mix ranges from 50 to 85 percent (by weight).[1] The evaporation of these solvents is the primary source of the VOC emissions from the coating facilities.

Other coating components include: (1) dispersants (1 to 5 percent by weight), to aid in deagglomeration of the magnetic particles; (2) conductive pigments (1 to 4 percent by weight), to prevent the buildup of static charge; (3) lubricants (less than 2 percent by weight), to minimize head-tape friction, and thus, wear on the tape; and (4) miscellaneous additives (1 to 3 percent by weight), such as mild abrasives for cleaning the head or fungicides to control mildew.[12,18]

3.2.1.2 Storage of Solvent. Generally, small tanks are used to store solvents used in the production of tape. These tanks may be horizontal or vertical and are sometimes below ground. The tanks operate at atmospheric pressure or slightly above atmospheric pressure. Typically, there are from 5 to 12 tanks ranging in capacity from 3,800 liters (1,000 gal) to 75,700 liters (20,000 gal) at a plant.[21-24]

3.2.1.3 Preparation of Coating Mix. The coating mix preparation room is separate from the coating line. One room may contain the mix preparation equipment for all the lines at the plant. One set of mix equipment can be used for more than one line or product. The number of pieces of mix equipment serving a line or product varies widely.[25-27]

The coating mix can be prepared on a batch or a continuous basis. The process begins with the blending of the components in low shear mixers. The mix is then transferred to a series of mills (ball, high speed, colloid, small media, or roll), where the dispersing action of beads, combined with the high shearing forces of the centrifugal mixing action, thoroughly disperse the aggregates of magnetic particles without reducing particle size. The final step in the process is polishing where the conductive carbon black is added. The completed mix is then continuously filtered in holding tanks.[28-31] Table 3-3 presents the range of values for selected properties of coating mixes used in the industry.

3.2.1.4 Conditioning. Prior to the application of the coating mix, the web must be prepared. Some precision products, such as videotape, have a nonmagnetic coating on the back of the tape (backcoating) that provides a conductive surface that minimizes static buildup, enhances handling, and increases abrasion resistance.[12,32] Backcoating is done prior to application of the magnetic coating, using the same solvents and the same equipment as are used in coating the tape with the magnetic material.[30] The thickness of the backcoat generally ranges from 1.0 to 1.5 μm (0.04 to 0.06 mils).[2]

As the web is unwound, it can be cleaned by wet or dry methods. It is then passed over rollers, which may be heated, to remove wrinkles from the web.[28]

3.2.1.5 Coating. In the coater, the web passes over a backup or support roll while the coating mix is applied either by another roll or by extrusion under pressure through a narrow slot in a die. The layer of wet coating mix applied ranges in thickness from 2.4 to 63.5 μm (0.09 to 2.5 mils).[1] The amount of coating mix applied by a coater is precisely measured and controlled.

There are four types of coaters used for production of all types of magnetic tape: extrusion (slot die), gravure, knife, and reverse roll (3-roll and 4-roll).[28] Figures 3-3 and 3-4 present schematic drawings of these coaters. Coaters range from 7.6 to 122 cm (3 to 48 in.) in width and operate at speeds ranging from 53 to 198 meters per minute (m/min) (175 to 650 feet per minute [ft/min]).[1] Extrusion and gravure coaters apply coatings uniformly at speeds in the higher end of the range. Knife coaters are not typically used in the manufacture of precision products such as computer tape. Reverse roll coaters are used in tape manufacturing when thicker coatings are required.[28,33] The range of coating mix viscosity that can be applied varies with the type of coater.

Immediately following the coater, the web is guided through an orientation field consisting of an electromagnet or permanent magnet, which aligns the individual magnetic particles in the direction of the intended recording. Webs from which flexible disks are produced do not go through the orientation process.[34,35]

High performance tapes require clean working conditions, especially in the coating application and oven areas, where dirt and unclean work areas may lead to poor tape quality.

3.2.1.6 Drying. The coated web then passes through a drying oven, where the solvents in the coating mix evaporate. Figure 3-5 presents a schematic of an air flotation oven, the type of oven typically used in this industry. In this oven, the web is supported on both sides by jets of drying air and never touches any metal, thus reducing abrasion and deformation and eliminating the need for reorientation of the magnetic particles after drying. Ovens range from 0.6 to 1.2 m (2 to 4 ft) in width and 12.2 to 30.5 m (40 to 100 ft) in length.[36,37] Oven temperatures range from 36° to 132°C (97° to 270°F).[3]

The airflow within the oven is countercurrent to the direction the web is traveling. The air is conditioned before entering the oven to remove dust particles and to adjust the temperature and humidity. Air from other parts of the coating line may be used, and the air may be recirculated within the oven. The airflow rate in the oven is adjusted so that the solvent concentration is maintained between 10 and 40 percent of the lower explosive limit (LEL)[1] of the solvent/air mixture for the particular solvent or solvent mix used.[1] Total individual oven exhaust flow rates range from 1.2 to ~5.7 standard m^3/s (2,500 to 12,000 standard cubic feet per minute [scfm]).[1] The higher airflows include some air from the coater that is routed through the oven. Airflow rates vary with the line size, solvent evaporation rates, and company practice.

3.2.1.7 Finishing Processes. The dry coated web is passed between several calendering rolls that compact the coating and smooth the surface finish.[28,34,35] The amount of calendering performed varies with the product, and not all products require compressing.[38] The final dry coating thickness on the web ranges from 1.0 to 10.8 µm (0.04 to 0.4 mils) depending on the product specification.[1]

Nondestructive quality testing is performed on up to 100 percent of the final product. The percentage of tape tested increases as the level of precision required in the final product increases. The web may then be slit into the desired tape widths by means of a rotary shearing operation. Flexible disks are not slit; instead, dies are used to punch the disks from the finished web.[34] The final product is then packaged. Some plants ship the coated webs in bulk to other facilities for slitting and packaging.

3.2.2 Uncontrolled VOC Emissions

3.2.2.1 Sources of Emissions and Factors Affecting Emissions. The VOC emissions are released from several points in the production of magnetic tape. These sources are identified in Figure 3-2. The potential uncontrolled VOC emissions from a facility are no less than the total amount of solvent used in the coatings and in cleanup of the coater and the ancillary equipment. All of the solvent from the coating operations will evaporate. Information on total solvent use in coatings in 1979 at 16 magnetic tape facilities shows that annual uncontrolled VOC emissions from coating operations at individual facilties ranged from 230 to 4,630 Mg (253 to 5,100 tons). The estimated average annual uncontrolled emissions rate from these facilities was 1,673 Mg (1,844 tons) per year.[39] Factors affecting the rate and location of VOC emissions are discussed below.

Emissions from outdoor solvent storage tanks result from both working losses and breathing losses due to diurnal temperature changes. The VOC emissions depend on the tank size, solvent vapor pressure, number of volume turnovers, and temperature.

In the coating preparation room, VOC's are emitted from the individual mixers and holding tanks, from the transfer of the coating mix between equipment, and from intermittent activities such as changing the filters in the holding tanks. The emissions will be intermittent or continuous, depending on whether the method of preparation is batch or continuous. There are no VOC emissions from mills that are permanently sealed and operate under pressure.

Emissions from the coating area come from the evaporative loss of solvent around the coating head and from the exposed web as it travels from the coater to the oven entrance. The magnitude of these losses is a function of line width and speed, coating thickness, volatility of the solvent(s), temperature, distance between coater and oven, and air turbulence in the coating area.

In the drying oven, the rate of evaporation of the solvents is affected by the temperature, airflow rate and direction, and the line speed. The airflow rate is adjusted to keep the VOC level below the LEL.

Of the total VOC emissions from the mix preparation room and the coating operation (coater head and drying oven), approximately 10 percent are emitted from the mix room and approximately 90 percent from the coating line.[40] Of the total VOC emissions from the coating operation, approximately 10 percent are emitted from the application/flashoff area and approximately 90 percent from the oven.[41] Because the oven evaporates all of the solvent from the coating, there are no VOC emissions from the steps after the oven.[42]

Information on 15 facilities in 1979 shows that the amount of solvent used for cleaning of coating equipment varied from 0 to 18 percent of the total solvent used at the plants; the average was 6 percent.[43] Much of this solvent stays in the liquid phase and can be reused or is disposed in accordance with solid waste and water quality regulations.[44]

3.2.2.2 Total Industry Uncontrolled Emissions. All the solvent used in the coating of magnetic tape is volatilized and, if not recovered or destroyed, could be released to the atmosphere. Thus, potential total industry uncontrolled emissions from coating operations are approximately equal to the total amount of solvent used by the industry in the coating operation. Data on total solvent use in coatings in 1979 at 16 facilities were used to estimate an average solvent use of 1,672 Mg (1,844 tons) per facility. Multiplying the average use value by the number of operating facilities using significant amounts of solvents in 1979 (21) resulted in an estimated 35,100 Mg (38,700 tons) of potentially uncontrolled VOC emissions from magnetic tape coating operations nationwide.[39]

3.3 BASELINE

The baseline emission level represents the level of control that is expected without a new source performance standard. Typically, this level of control reflects the emission levels required under existing State regulations. The baseline is used to evaluate the impacts of the regulatory alternatives to be selected for analysis.

3.3.1 Existing Emission Limits

Table 3-4 summarizes the State and local regulations applicable to VOC emissions from magnetic tape coating plants. Eleven States (with 16 plants) limit VOC emissions to 0.35 kg/ℓ (2.9 lb/gal) of coating applied, excluding water. This level of control is required by an existing Control Techniques Guidelines (CTG) document.[45] One State and two of California's air quality districts (with a total of seven plants) limit VOC emissions to 0.12 kg/ℓ (1.0 lb/gal) of coating. For 15 States, the National Ambient Air Quality Standard for ozone is the only applicable regulation. Of the 35 States without existing magnetic tape coating plants, 18 have applicable emission limits of 0.35 kg/ℓ (2.9 lb/gal) of coating applied, excluding water. Ten of these have exemptions for sources using or emitting less than a specified amount of coating or VOC's.

An examination of attainment and nonattainment area policies show that the majority of magnetic tape facilities will be subject to regulations no more stringent than that required by the CTG document.

3.3.2 Determination of Baseline Level

Because there are few State or local regulations that require controls on storage tanks less than or equal to 76 m^3 (20,000 gal) or coating preparation equipment, the baseline level for these sources is no control (0 percent) on all new plants.[46]

Two baseline levels were established for the coating operation (application/flashoff area and oven) based on existing State and local regulations. Some State regulations for ozone attainment areas would allow small new coating operations to be uncontrolled. Also, despite the potential for net credits resulting from solvent recovery, there are existing plants that do not control emissions from this source. Therefore, an uncontrolled (0 percent reduction) baseline was established.

Existing State and local regulations and the positive economics of solvent recovery necessitated the establishment of a second baseline level of control for the coating operation. Emissions from coating operations in ozone nonattainment areas are limited to 0.35 kilograms of VOC emitted per liter of coating applied (2.9 pounds of VOC emitted per gallon of coating applied). Assuming a typical coating composition of 0.72 kilogram of VOC per liter of coating (6 pounds of VOC per gallon of coating) [3.5 kilograms of VOC per liter of solids (29 pounds of VOC per gallon of solids)], a baseline level equivalent to an 83 percent reduction of VOC emissions from an uncontrolled coating operation was established.

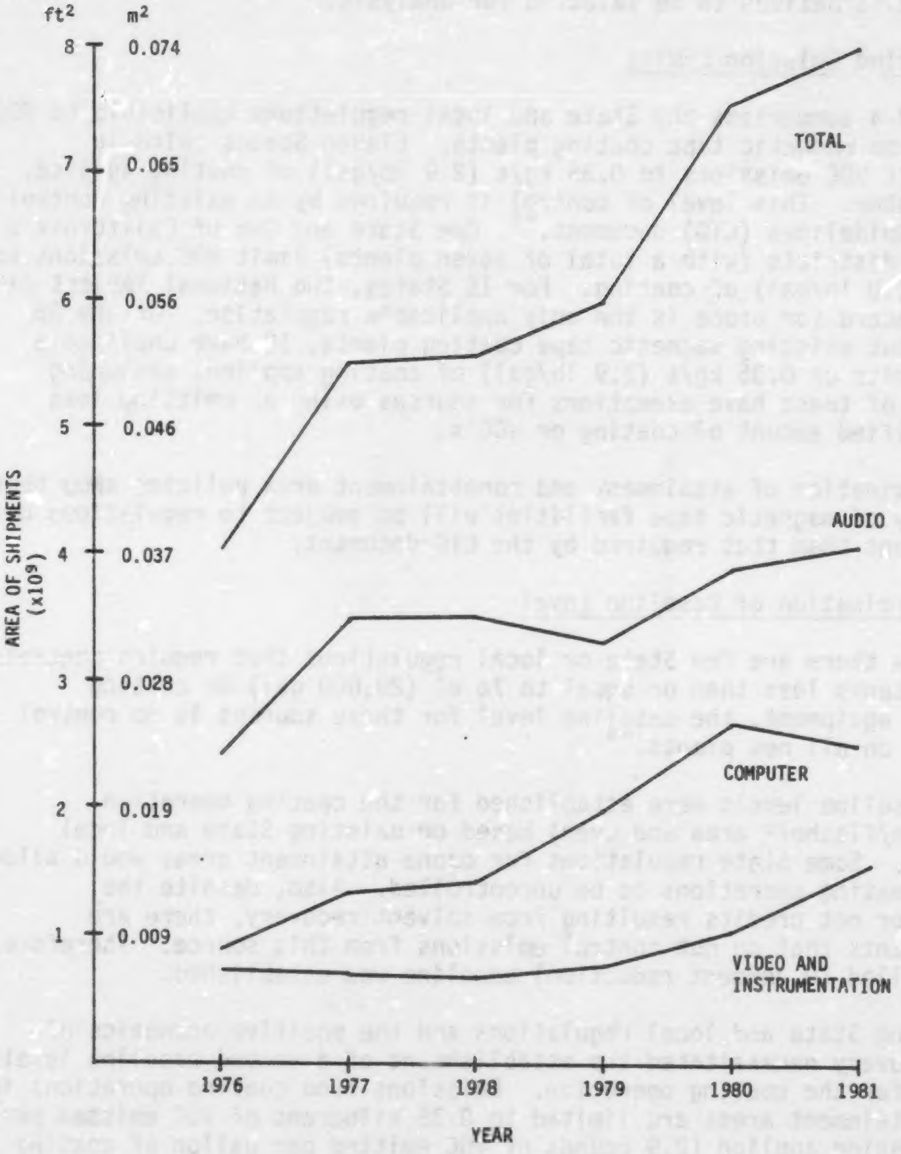


Figure 3-1. Annual shipments of blank magnetic tape.[3-5,47]

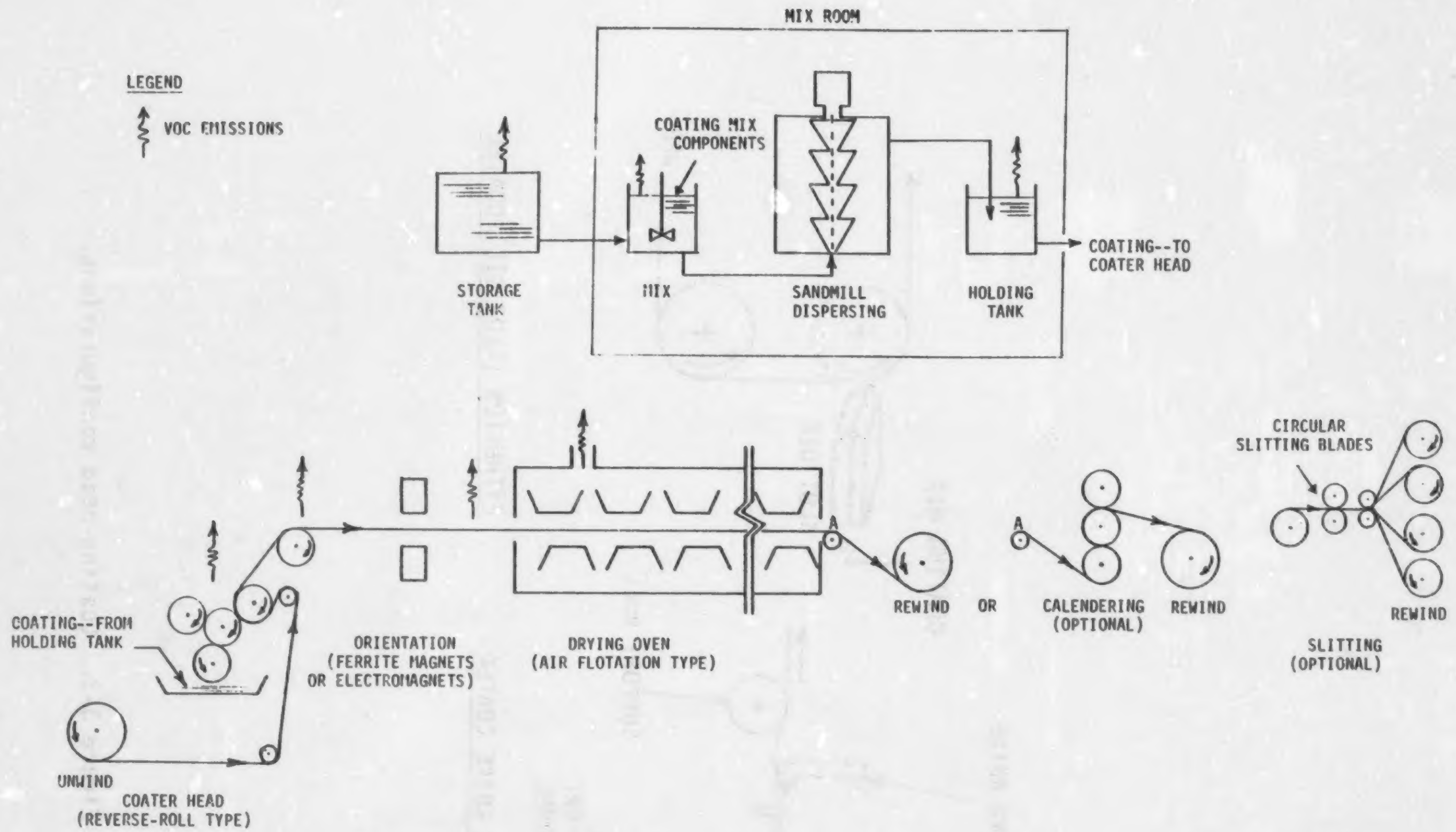
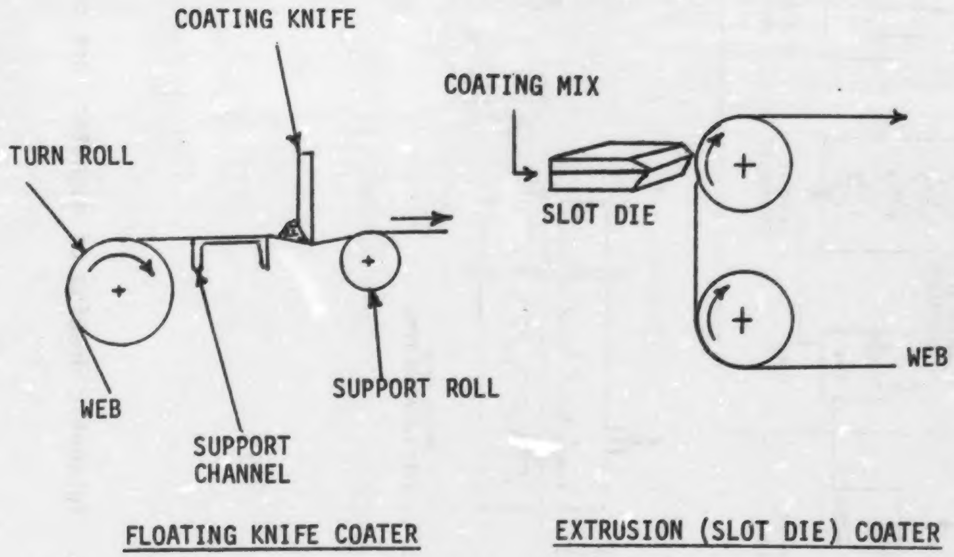

LEGEND
VOC EMISSIONS
MIX ROOM
COATING MIX COMPONENTS
STORAGE TANK
MIX
SANDMILL DISPERSING
HOLDING TANK
COATING--TO COATER HEAD
COATING--FROM HOLDING TANK
UNWIND
COATER HEAD (REVERSE-ROLL TYPE)
ORIENTATION (FERRITE MAGNETS OR ELECTROMAGNETS)
DRYING OVEN (AIR FLOTATION TYPE)
A
REWIND
OR
A
CALENDERING (OPTIONAL)
REWIND
CIRCULAR SLITTING BLADES
REWIND
SLITTING (OPTIONAL)

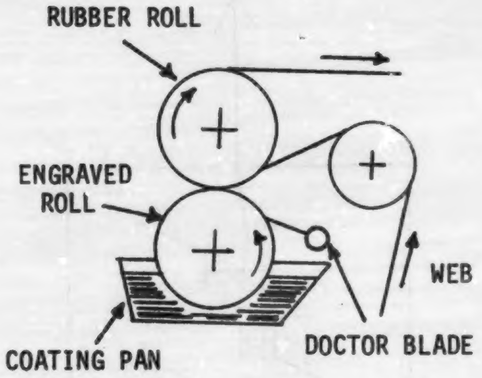
Figure 3-2. Schematic drawing of magnetic tape coating plant.[48]


COATING KNIFE
TURN ROLL
WEB
SUPPORT CHANNEL
SUPPORT ROLL
COATING MIX
SLOT DIE
WEB

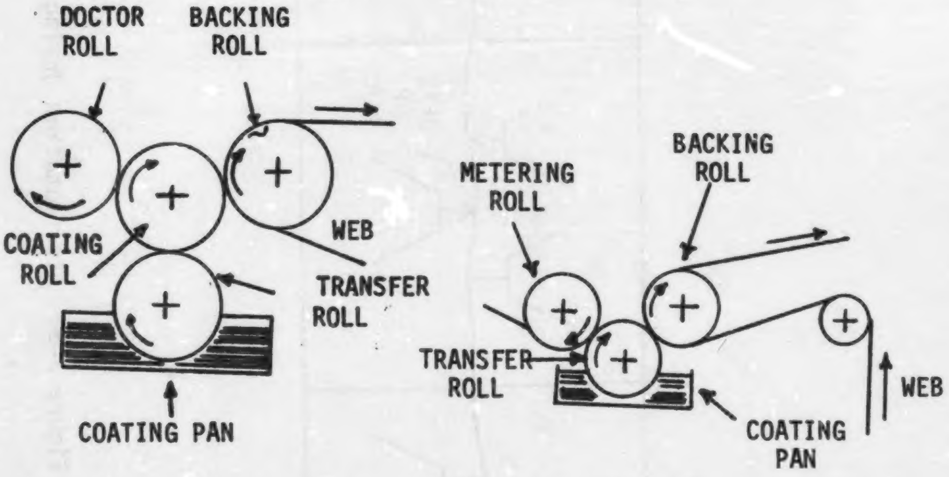
FLOATING KNIFE COATER

EXTRUSION (SLOT DIE) COATER

Figure 3-3. Coating head configurations.


RUBBER ROLL
ENGRAVED ROLL
WEB
COATING PAN
DOCTOR BLADE

GRAVURE COATER


DOCTOR ROLL
BACKING ROLL
COATING ROLL
WEB
TRANSFER ROLL
COATING PAN
METERING ROLL
BACKING ROLL
TRANSFER ROLL
WEB
COATING PAN

FOUR-ROLL REVERSE-ROLL COATER THREE-ROLL REVERSE-ROLL COATER

Figure 3-4. Metering-type coating heads.

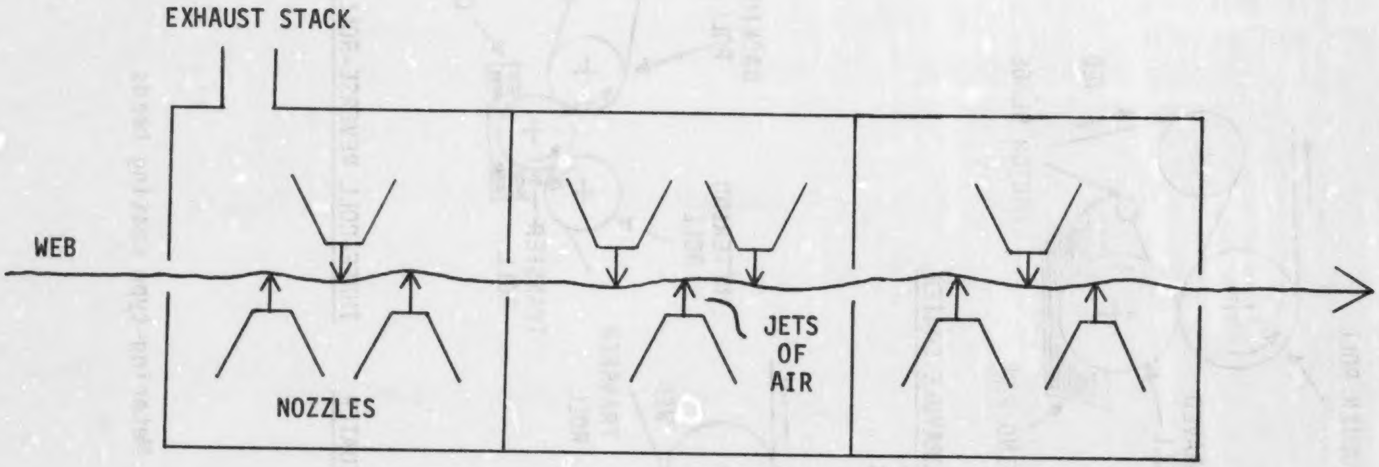

EXHAUST STACK
WEB
NOZZLES
JETS OF AIR

Figure 3-5. Air flotation drying oven.[48]

TABLE 3-1. MAGNETIC TAPE PRODUCT PARAMETERS

	Length[49,50]		Width[49,50]		Thickness[1]			
					Wet coating		Dry coating	
	m	ft	mm	in.	μm[a]	mil[a]	μm[a]	mil[a]
COMPUTER MEDIA								
Reel tape (10 in. reel)	732	2,400	13	0.5	38.1-50	1.5-2.0	7.6	0.3
Digital cassette	88	290	3.6	0.14				
Digital cartridge	46	150	6.4	0.25				
Magnetic cards	0.2	0.6	82	3.23	54	2.1	10.8	0.4
Flexible disks	--	--	133[b] 203[b]	5.25[b] 8[b]	12.7-32.0	0.5-1.2	2.5-5.1	0.1-0.2
BLANK AUDIO MEDIA								
Cassettes								
Pancakes[c]	2,195 3,048	7,200 10,000	3.8	0.15	32	1.2	4.9	0.2
Consumer tape	69-270	225-885	3.8	0.15	35.9	1.4	5.1	0.2
8-track								
Pancakes	2,560	8,400	6.4	0.25				
90-min	129	422	6.4	0.25	3.8-13.9	0.15-0.55	1.0	0.04
Open reel								
Pancakes	2,560	8,400	6.4	0.25				
Reels (5-, 7-, and 10-in.)	274-1,110	900-3,640	6.4	0.25				
Mastering tape								
Studio, reel equivalent	762	2,500	51	2				
Professional, reel equivalent	549	1,800	6.4	0.25				

(continued)

TABLE 3-1. (continued)

	Length[49,50]		Width[49,50]		Thickness[1]			
					Wet coating		Dry coating	
	m	ft	mm	in.	µm[a]	mil[a]	µm[a]	mil[a]
BLANK VIDEO MEDIA								
Broadcast tape								
Quadruplex	1,509	4,950	51	2				
Helical	945	3,100	25	1				
Closed circuit TV								
U-matic	183 or 366	600 1,200	19.1	0.75				
Consumer tape								
VHS	119 320	390- 1,050	13	0.5	34.4	1.3	4.6	0.2
Betamax	144 or 222	472 728	13	0.5				

[a] µm = micrometer; mil = 0.001 in.
[b] Values given are diameters of circular disks.
[c] Large reels used to ship bulk tape prior to cutting into shorter lengths.

TABLE 3-2. PLANTS COATING MAGNETIC TAPE[a]

Facility/location	Type of tape			
	Audio	Video	Computer	Other[b]
Alabama				
Sony, Dothan	x	x		
Ampex, Opelika	x	x		
Arizona				
IBM, Tucson				x
California				
Los Angeles Area				
Certron, Anaheim	x			
American Video Tape, Gardena		x		
Spectrotape, Colton	x	x		
Bay Area				
Precision Media, Sunnyvale		x	x	
Verbatim, Sunnyvale			x	
Xidex, Sunnyvale			x	
Ampex, Redwood City (research facility)	x	x		
Memorex, Santa Clara			x	
Tandy Magnetic Media, Santa Clara	x	x		
Ventura County				
3M, Camarillo			x	
San Diego County				
Spin Physics (Kodak), San Diego (research facility)		x	x	x
Colorado				
IBM, Boulder			x	
Brown Disk Manufacturing, Colorado Springs			x	
Connecticut				
Capitol Magnetic Products Glenbrook	x			
Columbia Magnetics, Danbury	x			
Georgia				
Columbia Magnetics, Carrollton	x			
Illinois				
TRI, Cary			x	
Wabash DataTech, Huntley			x	

(continued)

TABLE 3-2. (continued)

Facility/location	Type of tape			
	Audio	Video	Computer	Other[b]
Maryland				
Malco Plastics, Garrison				x
Massachusetts				
BASF Systems, Bedford	x	x	x	
Minnesota				
3M, Hutchinson	x	x		
New Jersey				
3M, Freehold	x			
Pennsylvania				
Pfizer, Easton[c] (research facility)	x	x		
South Dakota				
Syncom, Mitchell	x		x	
Tennessee				
NCR, Morristown				x
Texas				
Tandy Magnetics, Ft. Worth	x		x	
Graham Magnetics, Graham			x	

[a] As of September 1984.

[b] Includes bank transfer ribbons, mag cards, credit card tape, and other types of magnetic tape.

[c] Uses atypical coating formulations for research on magnetic particles.

TABLE 3-3. SELECTED COATING MIX PROPERTIES[1]

Parameter	Unit	Range
Solids	% by weight	15-50
	% by volume	10-26
VOC	% by weight	50-85
	% by volume	74-90
Density of coating	kg/l	1.0-1.2
	lb/gal	8-10
Density of coating solids	kg/l	1.2-4.0
	lb/gal	23-33
Resins/Binder	% by weight of solids	15-21
Magnetic particles	% by weight of solids	66-78
Density of magnetic material	kg/l	1.2-4.8
	lb/gal	10-40
Viscosity	Pa•s	2.7-5.0
	$lb_f \cdot s/ft^2$	0.06-0.10

TABLE 3-4. STATE REGULATIONS ON EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FROM THE MAGNETIC TAPE COATING INDUSTRY[51-54]

State	Regulation			Comments
	kg/ℓ	lb/gal	NAAQS[a]	
Alabama*	0.35	2.9		
Alaska			x	
Arizona*				Emission limit of 40 lb/day, if in excess of emission limit, 85 percent reduction required. Applies to organic emissions that have been heat cured, heat polymerized or baked. Applicable in Pima County.[b]
Arkansas[c]	0.36	3.0		
California*-- Bay Area	0.12	1.0		VOC emissions resulting from cleaning of coating line equipment are exempted.
San Diego County	0.265 0.12	2.2 1.0		0.265 for low solvent technology; 0.12 for add-on controls; for exemptions for sources emitting <6.5 kg/day (14.3 lb/day).
SCAQMD[d]	0.265	2.2		
Ventura Co.	0.120	1.0		
Colorado*	0.35	2.9		
Connecticut*	0.35	2.9		
Delaware[c]	0.35	2.9		Sources emitting <40 lb/day are exempted.
Florida[c]	0.35	2.9		Sources emitting <15 lb/day and <3 lb/h are exempted.
Georgia*	0.35	2.9		
Hawaii			x	
Idaho			x	

(continued)

TABLE 3-4. (continued)

State	Regulation kg/ℓ	Regulation lb/gal	Regulation NAAQS[a]	Comments
Illinois*	0.35	2.9		
Indiana[c]	0.35	2.9		
Iowa			x	
Kansas			x	
Kentucky[c]				Affected facility must not discharge >15% by weight of VOC compounds net input into facility; facility is exempted if coating is <2.9 lb/gal VOC (less water).
Louisiana[c]	0.35	2.9		Sources emitting <100 lb/d are exempted.
Maine[c]				For surface coating of paper: controlled through Maine Air Emission Licensing Mechanism. State requires Best Practical Treatment with at least 90% control.
Maryland*	0.35	2.9		
Massachusetts*	0.35	2.9		
Michigan[c]	0.35	2.9		Sources emitting <100 lb/d or <2,000 lb/month are exempted.
Minnesota*			x	
Mississippi			x	
Missouri[c]	0.35	2.9		Sources emitting <100 tons/yr in Kansas City or <50 tons/yr in St. Louis are exempted.
Montana			x	
Nebraska			x	
Nevada			x	

(continued)

TABLE 3-4. (continued)

State	Regulation kg/ℓ	lb/gal	NAAQS[a]	Comments
New Hampshire[c]	0.35	2.9		Sources emitting <100 tons/yr are exempted.
New Jersey*	0.35	2.9		
New Mexico			x	
New York	0.35	2.9		In metropolitan New York City, sources using <5.0 gal/day of coating are exempted; in upstate New York, sources using <30.0 gal/day are exempted.
North Carolina[c]	0.35	2.9		
North Dakota			x	
Ohio[c]	0.35	2.9		Coating lines using <3 gallons of coating per day are exempted.
Oklahoma				No discharge of more than 3,000 lb of organics in 1 day or more than 450 lb in 1 hour, 90% reduction by incineration, 85% reduction by adsorption or any process of equivalent reliability and effectiveness.
Oregon[c]	0.35	2.9		
Pennsylvania*	0.35	2.9		For existing sources only. State requires BACT for new sources.
Rhode Island[c]	0.35	2.9		
South Carolina[c]	0.35	2.9		
South Dakota*			x	
Tennessee*	0.35	2.9		For existing sources, State requires BACT; RACT or LAER for new sources.
Texas*	0.35	2.9		Applicable for Fort Worth facility only. Emissions limits are determined regionally.

(continued)

TABLE 3-4. (continued)

	Regulation			
State	kg/ℓ	lb/gal	NAAQS[a]	Comments
Utah[c]	0.35	2.9		
Vermont[c]	0.35	2.9		
Virginia[c]	0.35	2.9		Sources emitting up to 7.3 tons/yr, 40 lb/d, and 8 lb/h are exempted.
Washington[c]	0.35	2.9		Uncontrolled emissions allowed if VOC from coater, dryer, and flashoff area ≤600 lb in any given 24-h period.
West Virginia			x	
Wisconsin[c]	0.35	2.9		From a paper coating line or from each fabric coating applicator.
Wyoming			x	

*States with existing magnetic tape coating facilities.

[a] NAAQS = National Ambient Air Quality Standard for hydrocarbons only.

[b] Control required of captured emissions.

[c] State regulations on emissions of volatile organic compounds from the surface coating of paper and fabric.

[d] South Coast Air Quality Management District.

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4. EMISSION CONTROL TECHNIQUES

4.1 INTRODUCTION

Emissions from magnetic tape coating plants result from evaporation of solvent from solvent storage, coating mix preparation, coating application, and the curing of the coating in the ovens. A complete air pollution control system for a magnetic tape manufacturing plant consists of a VOC capture or containment system and an emission control device. This chapter describes the technology available for capture and control of emissions from all of the sources mentioned above and the expected levels of control achievable.

4.2 CONTROL SYSTEMS

Table 4-1 presents control devices currently used to control the coating operation emissions. The add-on technologies used to control VOC emissions are absorption, adsorption, condensation, and incineration. The theory and principles of these control systems are discussed briefly. The design and operation of the systems are presented with emphasis on factors that affect their use by the magnetic tape industry. Absorption systems are not discussed even though one is operated by a magnetic tape plant. This older system reportedly achieves a lower removal efficiency (85 to 95 percent) than do other types of control devices.[1,2]

4.2.1 Adsorption

Carbon adsorption has been used for 50 years by many industries to recover a variety of organics from solvent laden air (SLA) streams.[3] This technology reduces VOC emissions by adsorbing the organic compounds from the SLA onto the activated carbon bed. The organics are subsequently desorbed and recovered. The exhausts from more than one coating operation are commonly vented to the same carbon adsorber. There are two general types of adsorption systems, fixed-bed and fluidized-bed systems.

4.2.1.1 Fixed-Bed Carbon Adsorbers. For most of the 50 years that carbon has been used as a commercial adsorbant, it has been available only in a fixed-bed process. The typical thickness of a carbon bed within a vertical or horizontal metal vessel is 15 to 76 centimeters (6 to 30 inches).[4] The SLA is fed beneath the bed, and the organics are adsorbed as the air passes up through the bed. The SLA can also be fed with a downward flow to minimize bed lifting.[5,6] Most fixed-bed adsorbers have multiple beds to allow simultaneous adsorption and

TABLE 4-1. CONTROL DEVICES USED ON COATING OPERATIONS[7]

Control device	No. of control devices	Percentage
Carbon adsorber		
--fixed-bed	14	38.9
--fluidized-bed	3	8.3
Condenser system	2	5.6
Incinerator		
--production lines[a]	5	13.9
--research lines	2	5.6
Absorber	1	2.7
None[b]	9	25.0

[a] One company will change to a carbon adsorber in the near future.

[b] Companies with plans to install a control device in the near future are included in this category.

desorption and, thus, continuous operation. Figure 4-1 is a schematic of a two-unit fixed-bed adsorber. When the VOC concentration in the air discharge from a bed starts to increase, or at a preset time interval, the inlet SLA is routed to a different carbon bed, and the nearly saturated bed is regenerated. Regeneration is usually accomplished using low pressure steam. The steam heats the bed to desorb the solvents and acts as a nonflammable carrier gas. Typical steam requirements range from 4 to 9 kg of steam per kg of recovered solvent (4 to 9 pounds of steam per pound of recovered solvent).[8,9] After regeneration, the carbon bed is dried and cooled to improve the ability of the carbon to adsorb organic compounds. The mixture of steam and organic vapors exhaust from the adsorber and is condensed in a heat exchanger; the condensate is routed to a decanter (see Figure 4-1). In the decanter, the solvent floats on the organic-soluble water layer. Both water and organics are drawn off to storage or further treatment.

The parameters considered in the design of a fixed-bed carbon adsorption system are:

1. Type of solvent(s);
2. SLA inlet concentration;
3. SLA flow rate;
4. Temperature of the inlet SLA;
5. Relative humidity of the inlet SLA;
6. Type and amount of carbon;
7. Superficial bed velocity;
8. Bed pressure drop;
9. Cycle time;
10. Degree of regeneration of the carbon bed;
11. Pressure and temperature of steam; and
12. Condenser water outlet temperature.

The first five parameters are characteristics of the production process. The next three are design parameters for the adsorber. The remaining parameters are operating variables that affect the performance of the adsorber. Table 4-2 presents process parameters representative of several magnetic tape plants presently controlled by carbon adsorbers.

The SLA discharge from the oven must be cooled to below approximately 38°C (100°F) to optimize adsorption. A minimum of 20 to 40 percent relative humidity should be achieved, especially if ketones are to be adsorbed, because the heat dissipated by evaporation of water helps prevent heat buildup and subsequent bed fires.[10] Filtration equipment may also be required if there is particulate matter in the dryer exhaust. Particulate matter will coat the carbon and plug the voids between carbon particles, decreasing adsorbtivity and increasing pressure drop.

Major problems encountered in the operation of fixed-bed carbon adsorption systems in the magnetic tape industry include fouling of beds, corrosion, and bed fires. Carbon beds foul when the carbon cannot be regenerated with normal steam temperature and pressure. Fouling reduces adsorbtion and requires early replacement of the carbon. Carbon beds

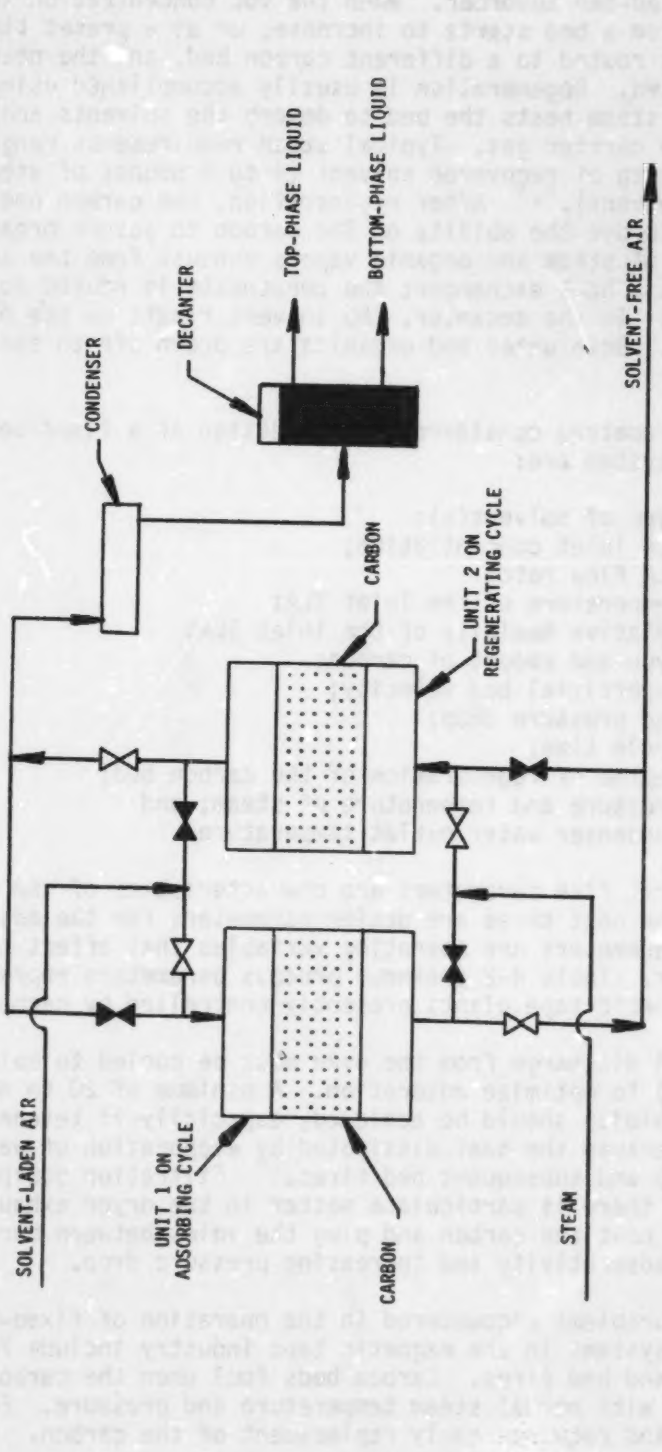
SOLVENT-LADEN AIR
UNIT 1 ON ABSORBING CYCLE
CARBON
STEAM
CONDENSER
DECANTER
TOP-PHASE LIQUID
BOTTOM-PHASE LIQUID
CARBON
UNIT 2 ON REGENERATING CYCLE
OPEN
CLOSED
SOLVENT-FREE AIR

Figure 4-1. Diagrammatic sketch of a two-unit, fixed-bed adsorber.

TABLE 4-2. PROCESS PARAMETERS FOR MAGNETIC TAPE PLANTS CONTROLLED BY FIXED-BED CARBON ADSORBERS[11]

Parameters	Range	Typical range
SLA flow rate	1.4 to 9.3 m^3/s (3,000 to 19,800 scfm)[a]	2.4 to 4.7 m^3/s (5,000 to 10,000 scfm)
SLA inlet concentration, ppmV[b]	50 to 7,000	≤2,500
SLA temperature	21 to 93°C (70° to 200°F)	27° to 49°C (80° to 120°F)
SLA relative humidity	30 to 55 percent	N/A[c]

[a] m^3/s = Cubic meters per second at standard conditions.
scfm = Standard cubic feet per minute where standard conditions are as defined in 40 CFR 60.2 (i.e., 20°C [68°F] and 101.3 kPa [29.92 in. Hg]).

[b] ppmV = Parts per million by volume.

[c] N/A = Not applicable.

can be fouled by high boiling compounds, high molecular weight compounds, and compounds that may polymerize or oxidize on the carbon particles.[12] In the magnetic tape industry, carbon life has been reported to vary from 6 months to 7 years.[13,14]

Corrosion can be a problem in fixed-bed carbon adsorption systems used to recover ketones because of the formation of acidic compounds in the wet steam. Ketones are commonly used at magnetic tape coating plants; corrosion can be avoided by the use of corrosion-resistant materials. Additional problems with ketones include plugging of the carbon bed by oxidation of the ketones. The oxidation reaction products of cyclohexanone are solids, which can rapidly plug the carbon adsorption system and cause corresponding loss in activity.[6]

Adsorption is an exothermic phenomenon; typically, 465 to 700 kilojoules (kJ) (200 to 300 British thermal units [Btu]) are generated per kg (pound) of solvent adsorbed.[10] If sufficient air is not present to carry this heat off, the bed may overheat, resulting in poor adsorption and, in extreme cases, bed fires.[15] Fires are predominantly associated with adsorption of ketone solvents and are more likely to occur after addition of fresh carbon.[16]

Solvents recovered by an adsorber may be purified by distillation and reused in the mix formulation. Typical purification systems consist of a decanter and several distillation columns. Caustic drying systems may also be used to remove water from the solvent. The materials of construction of the distillation system are a function of the types of solvents to be recovered. If ketones are present, expensive corrosion-resistant materials are required. The complexity and the recovery efficiency of the distillation system will vary with the amount of water in the recovered solvent, the number of solvent components, the desired purity of the recovered solvents, and line operations.

Long-term average VOC control efficiencies of 95 percent are achievable with well-designed and -operated fixed-bed adsorbers.[17] Magnetic tape manufacturers operate 14 fixed-bed carbon adsorption units. Most were built during the last 5 to 7 years. Two of these were tested by EPA and are described below.

Plant A installed its system in 1980 to recover toluene and tetrahydrofuran (THF) from a tape coating operation. The system consists of three beds and a purification section. The design flow for the adsorption unit is 6.3 cubic meters per second (m^3/s) (13,400 standard cubic feet per minute [scfm]).[18] Solvent concentrations in the inlet stream range from 50 to over 2,400 parts per million by volume (ppmV), depending on the number of coating lines operating, line speed, and coating thickness.[19] Outlet solvent concentrations vary from near 0 to 100 ppmV, depending upon adsorption-desorption cycle timing. The EPA test measured average VOC removal efficiency at 99.9 percent, using a gas chromatograph with flame-ionization detector.[20]

Plant B installed its adsorber in 1975 to recover solvent from two coating lines. The adsorber was redesigned in 1978. The solvent used at the plant is a mixture of toluene, THF, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and cyclohexanone.[21] The recovery section consists of three pairs of fixed carbon beds and a purification system. Only two pairs of beds are operated at any given time while the third pair is either down for maintenance or on standby.[21] The design flow rate for the adsorber units is 9.7 m^3/s at 27°C (20,600 actual cubic feet per minute [acfm] at 80°F) with inlet solvent concentrations ranging from 2,000 to 5,000 ppmV depending on the line speed, number of lines in operation, and the type of magnetic tape being produced. Outlet concentrations from the beds varied from 35 to 350 ppmV.[22] The efficiencies of the beds ranged from 91 to 98 percent.[22] The efficiency varied with the age of the carbon.[22] Solvent vapor concentrations were measured using the same procedure used for Plant A.

4.2.1.2 Fluidized-Bed Carbon Adsorbers. In fluidized-bed systems, adsorption and desorption are carried out continuously in the same vessel. Figure 4-2 presents a flow diagram of a fluidized-bed carbon adsorber. The system consists of a multistage, countercurrent, fluidized-bed adsorption section; a pressure-sealing section; and a desorption section. Nitrogen gas is used as a carrier to remove the solvent vapors from the desorption section. The pressure-sealing section prevents air from entering the mixture of solvent and nitrogen vapors. The regenerated carbon is carried by air from the bottom to the top of the column.

The SLA is introduced into the bottom of the adsorption section of the column and passes upward countercurrent to the flow of carbon particles. Adsorption occurs on each tray as the carbon is fluidized by the SLA. The carbon falls down the column through a system of overflow weirs. Below the last tray, the carbon falls to the desorption section where indirect heating desorbs the organic compounds from the carbon; hot nitrogen gas passes through the bed countercurrent to the carbon flow and removes the organic compounds. The desorption temperature is normally around 121°C (250°F) but can be raised to 260°C (500°F) to remove buildup of high-boiling materials. The desorption section is maintained continuously at the temperature required to volatilize the adsorbed compounds.[23] The solvent and nitrogen mixture is directed to a condenser where the solvent can be recovered for reuse. The nitrogen is sent through the "secondary adsorber" (top layer of carbon in the desorption section), which removes residual solvent from the nitrogen, and is then recycled.

The microspherical particles of carbon used in a fluidized-bed are formed by spray-drying molten petroleum pitch. The carbon particles are easily fluidized and have strong attrition resistance.[23] The adsorptive properties of carbon made this way are similar to those of other activated carbons.[24]

The parameters considered in design of a fluidized-bed carbon adsorber system are:

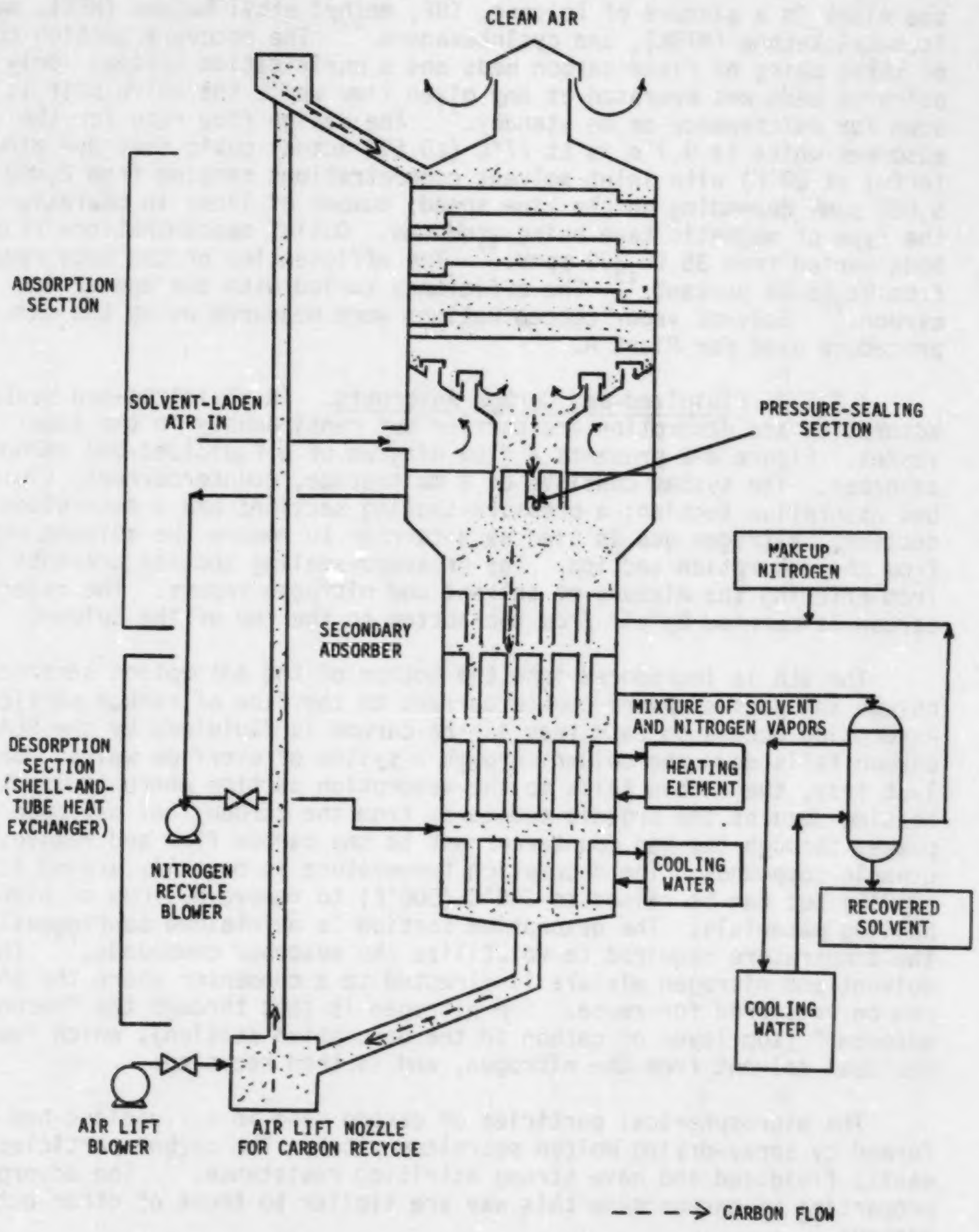
CLEAN AIR
ADSORPTION SECTION
SOLVENT-LADEN AIR IN
PRESSURE-SEALING SECTION
MAKEUP NITROGEN
SECONDARY ADSORBER
MIXTURE OF SOLVENT AND NITROGEN VAPORS
DESORPTION SECTION (SHELL-AND-TUBE HEAT EXCHANGER)
HEATING ELEMENT
COOLING WATER
NITROGEN RECYCLE BLOWER
RECOVERED SOLVENT
COOLING WATER
AIR LIFT BLOWER
AIR LIFT NOZZLE FOR CARBON RECYCLE
CARBON FLOW

Figure 4-2. Fluidized-bed carbon adsorption system.

1. Type of solvent(s);
2. SLA inlet concentration;
3. SLA flow rate;
4. Temperature of the inlet SLA;
5. Relative humidity of the inlet SLA;
6. Superficial bed velocity;
7. Bed pressure drop;
8. Rate of carbon flow;
9. Degree of regeneration of the carbon (bed); and
10. Condenser water outlet temperature.

The first five parameters are characteristics of the production process. The next two are design parameters for the adsorber. The next three are operating parameters. The rate of carbon flow is set by the operator to achieve desired control efficiency. Just as with the fixed-bed, the dryer exhaust gas (the SLA) must be cooled before it reaches the adsorber in order to optimize the carbon's adsorbability. Pressure drop per stage normally ranges from 1 to 2 kilopascals (kPa) (4 to 8 in. water), with six to eight stages required, depending on the application. The pressure drop across the entire bed is 6 to 16 kPa (24 to 64 in. water). The gas velocity through the adsorption section is as high as 1 m/s (200 fpm), which is two to four times that used in fixed bed adsorbers. For a given flow rate, this high gas velocity reduces the cross-sectional area of the bed.[23]

The primary problem that may occur with operation of fluidized-bed adsorbers is fouling of the carbon. The same factors that affect fouling of carbon in fixed-bed adsorbers also affect the carbon used in fluidized-bed adsorbers. Corrosion is generally not a problem in fluidized-bed adsorbers; because stripping is by nitrogen rather than steam, the water content of the recovered solvent is low, typically 5 percent or less. The only water present in the recovered solvent is that which was adsorbed from the SLA. Thus, generally, the carbon adsorber need not be made of expensive corrosion-resistant materials. Bed fires are generally not a problem in fluidized-bed adsorbers because the relatively high superficial velocities and the intimate contact between the SLA and activated carbon eliminate the possibility of hot spot formation. However, hot spots can form, depending on the solvents adsorbed, if the bed is shut down before being completely stripped. Shutdowns resulting from mechanical problems could create conditions leading to potential bed fires.[6]

A distillation system may not be required for a fluidized-bed adsorption system because of the low water content of the recovered solvent (less than 5 percent water by weight).[25] Cleanup can be as simple as drying by the addition of caustic soda. Of the three facilities in this industry using a fluidized-bed system, two facilities dry with caustic soda, and one distills the recovered solvent.[26]

Fluidized-bed systems are new to this industry. Consequently, only limited test data are available. At one facility, the design efficiency is 96 to 98 percent for SLA concentrations of 2,000 ppmV.[26] The actual efficiency is somewhat less (93 to 94 percent) because of lower inlet concentrations (200 to 2,000 ppmV), contamination of the carbon with benzoic acid, and varying SLA operating conditions.[27,28]

4.2.1.3 Disposable-Canister Unit Carbon Adsorber. In this system, a prefabricated canister containing activated carbon is connected to the emission source vent. The principle of operation is the same as that of a fixed-bed carbon adsorber except that there is no regeneration of spent carbon. Rather, the canister and contents are removed for disposal, and a new canister is installed. The actual useful life depends on the size of the canister and the type and amount of vapors to which the carbon is exposed.[29]

As with other fixed-bed systems, bed overheating can be a problem if these systems are used to recover ketones. Overheating can be circumvented by keeping the carbon damp.[30] However, keeping the carbon damp reduces the effectiveness of carbon adsorption; consequently, a larger unit must be provided than would be indicated from the design calculations involving adsorption rates on dry carbon.[6]

Disposable canisters are used for flows generally less than 0.05 m³/s (100 acfm) with low organic loading. They can be used to control emissions from solvent storage tanks and mix room equipment, which have inherently low flow rates and solvent concentrations. Although no magnetic tape line is known to use canisters in this manner, they have been used to control solvent storage tank and reactor vessel emissions in other industries.[29]

4.2.2 Condensers

Condensers recover VOC emissions by cooling the SLA below the dew point of the solvent (or solvent mixture) and collecting the droplets of solvents. The temperature reduction necessary to condense the solvent vapor depends on the vapor pressure of the solvents in the gas stream. Two types of commercially available condensation systems have been used to recover VOC from drying ovens at magnetic tape plants. These systems differ (1) in the design and operation of the drying oven (i.e., use of nitrogen or air in the oven) and (2) in the method of cooling the SLA (i.e., liquid nitrogen or refrigeration).

4.2.2.1 Condensation System Using Nitrogen Atmosphere. Figure 4-3 presents a flow diagram of a condensation system that uses a nitrogen-blanketed drying oven and a nitrogen-cooled heat exchanger. The inerting curtains shown in Figure 4-3 prevent both airflow into the oven and VOC flow from the oven. Fume collection hoods may also be located near the ovens and curtains to capture any gases escaping from these areas.

Nitrogen is used in the drying oven to permit operation with high solvent vapor concentrations without danger of explosion. The nitrogen recycled through the oven is monitored and operated to maintain solvent vapor concentrations of 10 to 30 percent, by volume.[31] The higher the solvent concentration, the smaller the auxiliary equipment required and

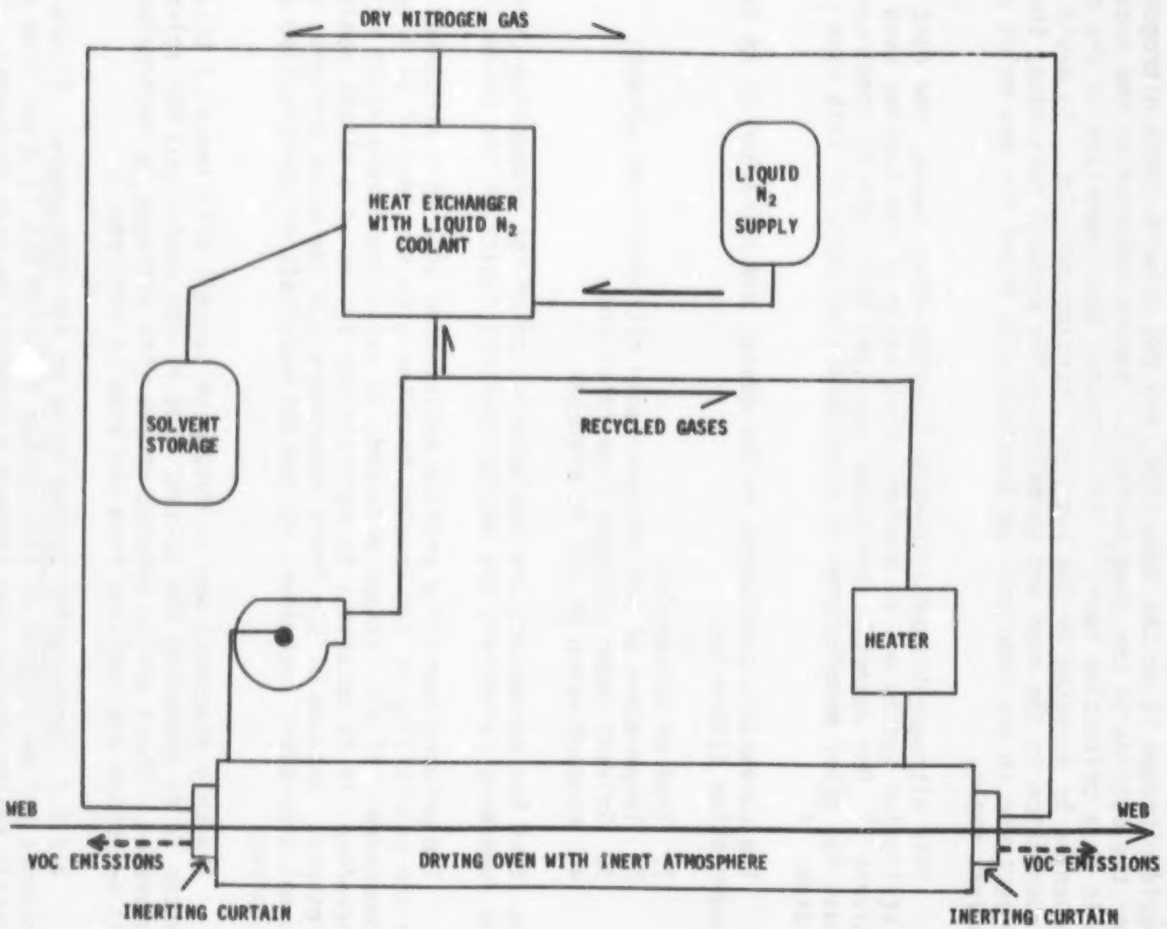
DRY NITROGEN GAS
HEAT EXCHANGER WITH LIQUID N_2 COOLANT
LIQUID N_2 SUPPLY
SOLVENT STORAGE
RECYCLED GASES
HEATER
WEB
VOC EMISSIONS
DRYING OVEN WITH INERT ATMOSPHERE
INERTING CURTAIN
WEB
VOC EMISSIONS
INERTING CURTAIN

Figure 4-3. Schematic of condensation system using nitrogen.

the less the makeup nitrogen required. This allows economical solvent recovery.

Solvents are recovered by sending a bleed stream of approximately 1 percent of the recycle flow through a shell-and-tube condenser.[32] The liquid nitrogen is on the tube side, and the solvent-laden nitrogen passes over the outside of the tube surfaces. Vapors condense on the tubes and drain to a collection tank.[33] The nitrogen that vaporizes in the heat exchanger is directed to the oven and inerting curtains. To avoid solvent condensation in the oven and to maintain the product cure rate, the temperature in the oven must be substantially above the dew point of the solvent vapor.

This nitrogen-blanketed system is water-free; hence, the cost of a distillation system may be avoided, especially if the coating uses a single solvent.[34] One magnetic tape plant now uses this type of condenser, and at least one other manufacturer is considering purchase of this type of system.[35,36]

The parameters considered in the design and operation of an inert gas condensation system are:

1. Type of solvent(s);
2. Temperature of the solvent-laden nitrogen bleed stream;
3. Solvent-laden nitrogen flow rate; and
4. Concentration of VOC in nitrogen.

The first two parameters are characteristics of the production process. The remaining parameters are design characteristics of the condenser.

The primary operating problem anticipated with this condenser design is the possibility of air leaking into the oven and loss of an inert atmosphere. If air leakage occurred, an explosion hazard might exist; therefore, it is necessary to maintain the system at a slight positive pressure. Because of the inert atmosphere and low water content, corrosion is not a problem; therefore, no special materials of construction are required.

The only practical way to determine overall efficiency of this type of system is by measuring the solvent used at the coater and the solvent recovered. There are no exhaust stacks (the nitrogen is recirculated), and all emissions are fugitive from the ends of the oven.[37]

4.2.2.2 Condensation System Using An Air Atmosphere. Figure 4-4 presents a flow diagram of this system in which SLA is drawn from a tightly sealed drying oven through a counterflow heat exchanger. There, the SLA is cooled to reduce the heat load on the refrigerated condenser. The solvent and water formed by the refrigerated condenser are stored for further processing.[38] The cooled solvent-free air is then blown back through the heat exchanger for preheating before being returned to the oven. Drying ovens used with this system must be relatively tight, i.e., have minimum air leakage and be equipped with solvent vapor

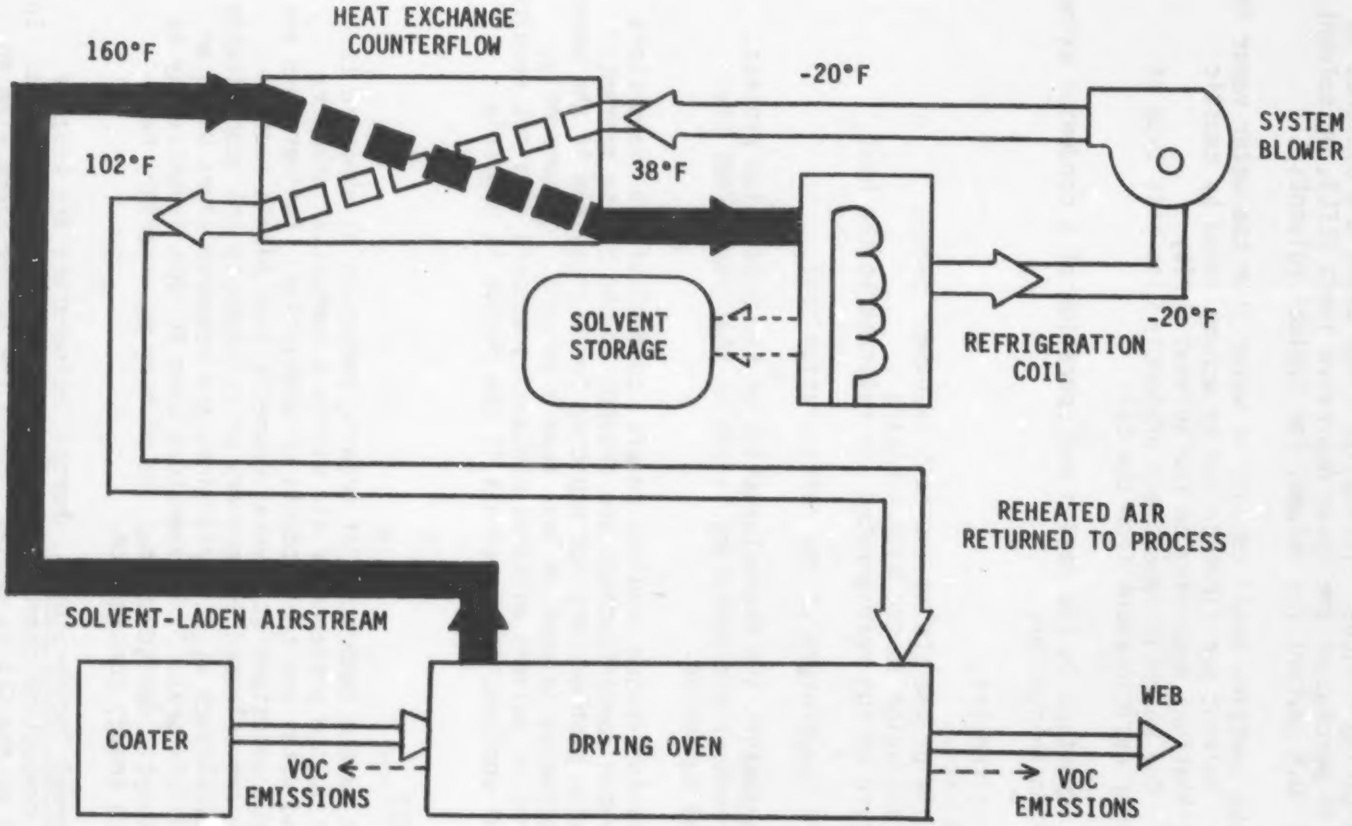
HEAT EXCHANGE COUNTERFLOW
160°F
102°F
38°F
-20°F
SYSTEM BLOWER
-20°F
SOLVENT STORAGE
REFRIGERATION COIL
REHEATED AIR RETURNED TO PROCESS
SOLVENT-LADEN AIRSTREAM
COATER
VOC EMISSIONS
DRYING OVEN
WEB
VOC EMISSIONS

Figure 4-4. Flow diagram of condensation system using an air atmosphere in the drying oven.

concentration monitoring devices. Typically, these ovens are designed to operate at 40 to 50 percent of the lower explosive limit (LEL), or solvent concentrations of <0.5 percent (by volume) for typical solvents.[35]

The condensate contains small amounts of water from the water vapor in the oven exhaust. Solvent purification can be accomplished by caustic drying or by distillation, depending on the solvent purity specifications.[39] One magnetic tape plant presently uses this type of condenser to recover cyclohexanone from the SLA.

The factors important in the design and operation of a condenser using a counterflow heat exchanger are:

1. Type of solvent(s);
2. SLA flow rate;
3. Temperature of the SLA at the heat exchanger inlet;
4. SLA concentration in the oven exhaust;
5. Temperature of the refrigerated air returned to the heat exchanger; and
6. Operating temperature of the refrigeration coil.

The first four parameters are characteristics of the production process. The remaining parameters are operating variables that may affect the performance of the condenser.

This condensation system requires careful control of the evaporators when high water vapor concentrations are present in the SLA to prevent freezing. Corrosion problems are not expected for this system if the water content of the recovered solvent is less than 5 percent. Consequently, recovery of ketones or solvent mixtures containing ketones does not require the use of special construction materials if the device is properly operated.

4.2.3 Incinerators

Incineration is the combustion of organic compounds by exposure to high temperatures in the presence of air within a combustion chamber; carbon dioxide and water are the products of combustion. Incinerators are used to control VOC emissions at several magnetic tape plants (see Table 4-1). They are selected if recovery of solvents is not economically feasible or practical such as at small lines and research lines using a variety of solvent mixtures.[40] Incinerators used in this industry may be of thermal or catalytic design and may use primary or secondary heat recovery to reduce energy consumption.

4.2.3.1 Thermal Incinerators. Thermal incinerators are usually refractory-lined combustion chambers with a burner located at one end. In these units, part of the SLA is passed through the burner along with an auxiliary fuel. The combustion gases exiting the burner blend with the by-passed SLA and combust the solvents in the SLA. With most solvents, complete destruction is obtained in 0.75 seconds at temperatures of 870°C (1600°F).[41,42]

Factors important in incinerator design and operation include:

1. Type and concentration of VOC;
2. SLA flow rate;
3. SLA temperature at incinerator inlet;
4. Burner type;
5. Efficiency of flame contact (mixing);
6. Residence time;
7. Auxiliary fuel firing rate;
8. Amount of excess air;
9. Firebox temperature; and
10. Preheat temperature.

The first three parameters are characteristics of the production process. The next three parameters are characteristics of the design of the incinerator. The auxiliary fuel firing rate is determined by the type and concentration of VOC, the SLA flow rate, firebox temperature, and the preheat temperature. The last four parameters are operating variables that may affect the performance of the incinerator. With well-designed and -operated incinerators, VOC destruction efficiencies of 98 percent or better can be achieved.[41,42]

At magnetic tape plants using thermal incinerators for control of VOC emissions, a typical VOC concentration is ~2,500 ppmV of solvents such as MEK, MIBK, toluene, and cyclohexanone. The SLA flows typically range from 1.4 to 4.7 m^3/s (~3,000 to 10,000 scfm).[7,43]

4.2.3.2 Catalytic Incinerators. Catalytic incinerators use a catalyst to promote the oxidation rate of VOC. The SLA is preheated by a burner or heat exchanger and then brought into contact with the catalyst bed where oxidation occurs. Common catalysts used are platinum or other noble metals on alumina pellets or honeycomb support. Catalytic incinerators can achieve destruction efficiencies similar to those of thermal incinerators while operating much cooler, i.e., 400° to 540°C (750° to 1000°F). Thus, catalytic incinerators can operate with significantly lower energy costs than can thermal incinerators.[44] Construction materials may also be less expensive because of the lower operating temperatures.

Factors important in the design and operation of a catalytic incinerator include the factors affecting thermal incinerators as well as the operating temperature range of the catalyst. The operating temperature range for the catalyst sets the upper VOC concentration that can be incinerated. For most catalysts on alumina, exposure to temperatures greater than about 700°C (1300°F) severely reduces catalyst activity.[45] Consequently, the heating value of the inlet stream must be limited. Typically, inlet VOC concentrations must be less than 25 percent of the LEL. The possibility of catalyst poisoning is also a limiting factor in the use of catalytic incineration.[6]

4.2.3.3 Heat Recovery. Heat recovery offers a means of reducing the energy consumption of the incinerator or another process in the plant. Primary heat recovery refers to the transfer of heat from the hot incinerator effluent to a relatively cool incinerator inlet VOC stream. Secondary heat recovery refers to exchange of heat from the incinerator to any other process.

Plants using primary and secondary heat recovery with typical thermal efficiencies can achieve overall heat recoveries of 70 to 80 percent.[46] Actual overall energy savings obtained will vary with the VOC concentration in the oven exhaust, the incinerator operating temperature, and the ability of the plant to incorporate primary and secondary heat recovery.

4.2.4 Flare Systems

Flares are a method of controlling VOC emissions by thermal destruction. Although flares are a proven technology that is used for controlling a wide range of gaseous emissions in other industries, flares are not presently used in the magnetic tape coating industry. A brief description of flare technology, factors affecting performance, and the potential of flares as a VOC control method for ovens, mix preparation equipment, and solvent storage tanks are discussed in this section.

4.2.4.1 Operating Principles. Flaring is an open combustion process in which the oxygen required for combustion is provided by the air around the flame. Good combustion in a flare is governed by flame temperature, residence time of components in the combustion zone, turbulent mixing of the components to complete the oxidation reaction, and the amount of oxygen available for free radical formation.[47]

There are two types of flares: ground level flares and elevated flares. In an elevated flare system, process off-gases are sent to the flare through the collection heater. The off-gases entering the heater can vary widely in volumetric flow rate, moisture content, VOC concentration, and heat value. They can be used for almost any VOC stream and can handle fluctuations in VOC concentration, flow rate, and inerts content.[47]

The VOC stream enters at the base of the flame where it is heated by already burning fuel and pilot burners at the flare tip. If the gas has sufficient oxygen and residence time in the flame zone, it can be completely oxidized. The high volume of fuel flow in a flare requires more combustion air at a faster rate than simple gas diffusion can supply, so flare designers add steam or forced air injection nozzles to increase gas turbulence in the flame boundary zones and, thus, draw in more combustion air and improve combustion efficiency. Steam injection promotes smokeless flare operation by minimizing the cracking reactions that form carbon, but it also causes increased noise and cost. Typically 0.15 to 0.5 kg of steam per kg of flare gas (0.15 to 0.5 lb of steam per lb of flare gas) is required; with air-assisted flares, steam is not required. Air assist is rarely used on large flares because airflow is difficult to control when the gas flow is intermittent. Gases with heating values of below about 18 MJ/scm[47] (500 Btu/scf) may be flared smoke free with steam or air assist.

Ground flares are usually enclosed and have multiple burner heads that are staged to operate based on the quantity of gas released to the flare. The energy of the flared gas itself (because of the high nozzle pressure drop) is usually adequate to provide the mixing necessary for smokeless operation and air or steam assist is not required. A fence or other enclosure reduces noise and light from the flare and provides some wind protection. Ground flares are less numerous and have less capacity than elevated flares. Typically they are used to burn gas "continuously" while steam-assisted elevated flares are used to dispose of large amounts of gas released intermittently.[47]

4.2.4.2 Design Factors. The factors important in the design and operation of a flare are:

1. Flammability limits of the gases flared;
2. Auto-ignition temperatures of the gases;
3. Heating values of the gases;
4. Density of the gases; and
5. Efficiency of flame contact (mixing).

4.2.4.3 Control Efficiency. After reviewing the results of several studies, the EPA has concluded that 98 percent combustion efficiency can be achieved by steam-assisted flares burning gases with exit flow velocities less than 19 m/s (63 ft/sec) and with heat contents over 11 MJ/scm (300 Btu/scf) and by flares operated without assist with exit flow velocities less than 18 m/s (60 ft/sec) and burning gases with heat contents over 8 MJ/scm (200 Btu/scf).[47]

4.2.5 Conservation Vents and Pressure Relief Valves

Conservation vents have long been used to minimize tank losses from a variety of industries including magnetic tape manufacturers.[48-50] These vents are valves that are permanently attached to the outside of sealed, vapor-tight vessels. These valves open when either positive or negative pressure within a vessel exceeds predetermined values. These pressure and vacuum settings are achieved by weights inside the vent. Conservation vents reduce VOC emissions that would occur because of cyclic changes in the temperature of the liquid inside a vessel. These losses are called breathing losses.

Figure 4-5 presents a diagram of a conservation vent. The vessel pressure is applied to the underside of the pressure pallet and the top side of the vacuum pallet. As long as the vessel pressure remains within the valve pressure and vacuum settings, the pallet remains in contact with the seat rings, and no venting or breathing takes place. The pressure pallet lifts from its seat ring when the vessel pressure reaches the valve pressure setting and allows the excess pressure to vent to the atmosphere. As the vessel pressure drops below the valve setting, the pressure pallet returns to the closed position. For a negative pressure (vacuum), the vacuum pallet lifts from its seat ring when the vessel vacuum reaches the valve vacuum setting, allowing air to flow into the vessel to relieve the excess vacuum condition. The vacuum

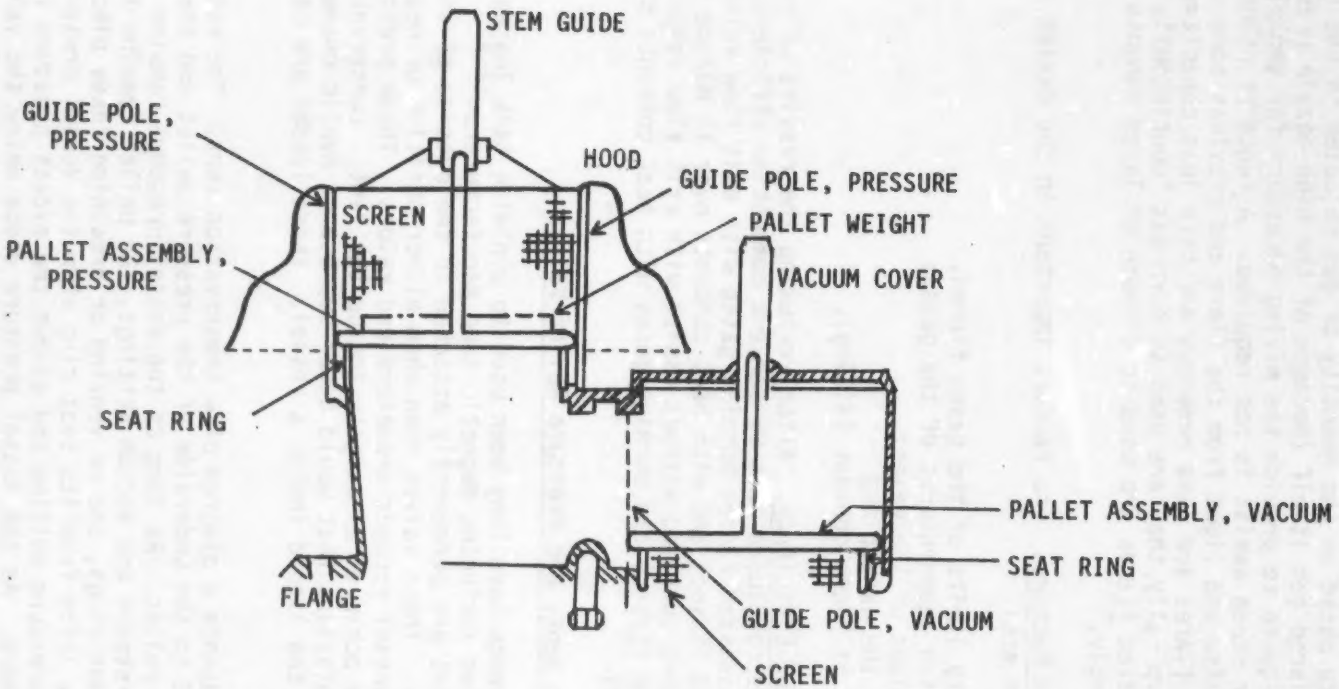
STEM GUIDE
GUIDE POLE, PRESSURE
HOOD
GUIDE POLE, PRESSURE
SCREEN
PALLET WEIGHT
PALLET ASSEMBLY, PRESSURE
VACUUM COVER
SEAT RING
PALLET ASSEMBLY, VACUUM
SEAT RING
FLANGE
GUIDE POLE, VACUUM
SCREEN

Figure 4-5. Diagram of conservation vent.

pallet returns to its normal position as the vessel vacuum drops below the valve vacuum setting.[51] Conservation vents will not prevent the tank from venting when it is filled (working losses) because the internal pressure will exceed the set pressure on the valve.

The amount of VOC emission reduction achieved by conservation vents depends on the solvent vapor pressure, the diurnal temperature change, the tank size, and the vent pressure and vacuum settings. Breathing and working losses from solvent storage tanks can be estimated using emission equations developed by the American Petroleum Institute.[52] Assuming a yearly average diurnal temperature change of 11°C (20°F) and the model storage tank parameters, these equations yield estimates for breathing losses of 17 to 85 percent of the total annual emissions from solvent storage tanks.[53] Conservation vents set at 0.215 kPa (1/2 ounce) vacuum and 17.2 kPa (2.5 psig) pressure control all of the breathing losses, for an average overall efficiency of 50 percent.[53]

A pressure relief valve operates in a manner similar to that of the conservation vent. These valves operate at higher pressures achieved by internal springs, not weights, and usually do not have any vacuum settings. The pressure relief valves control all of the breathing losses and much of the working losses. Based on the average vapor pressures of the solvents in this industry and a pressure setting of 103 kPa (15 psig), a control efficiency of 90 percent was calculated for pressure relief valves.

4.3 VOC EMISSION CAPTURE SYSTEMS

Although some web coaters sweep VOC from the coating room to the atmosphere as part of a ventilation program to minimize worker exposure, many others use a capture system to gather emissions from storage tanks, mix preparation equipment, coating operations, and miscellaneous other sources to deliver them to emission control devices. If a source is enclosed, total capture may be achieved. Otherwise, the ratio of VOC emitted to VOC delivered to the control device, or "capture efficiency," is a function of the design and the specifics of the operation. This section contains a description of capture systems used on solvent storage tanks, mix rooms, coaters, and drying ovens and identifies factors that affect their performance.

4.3.1 Capture of Emissions From Solvent Storage Tanks

The VOC emissions from solvent storage tanks in this industry can be 100 percent captured if the tanks are sealed and the conservation vents are vented to the control device. At least six magnetic tape coating plants control VOC emissions from solvent storage tanks by venting into the carbon adsorber that serves the coating operation.[54]

4.3.2 Capture of Emissions From Mix Rooms

The VOC emissions from equipment in the mix room may be captured to varying degrees by a room ventilation system, by covering all mix tanks (using pressure-tight covers) and venting to the control device, or by ventilation hoods.

Room ventilation systems evacuate air from the room or rooms in which the coating mix is prepared. Ideally, the air exhausted by this type ventilation system may be used as oven make-up air and then sent to a control device. Presently, it is more often discharged directly to the atmosphere. Three plants are known to vent the room air to the atmosphere, oven, or control device.[54]

By tightly covering, sealing, and venting the mix equipment (i.e., premixers, holding tanks), effective capture of emissions can be achieved with a minimum airflow rate. Forced ventilation of tanks, however, can affect the composition of the coating mix; thus, use of such systems requires regular monitoring of the coating mix composition.[55] The SLA discharged from the room or mix equipment can be used as part of the oven make-up air or sent to the control device. Seven plants are known to cap and vent mix equipment through the oven or directly to a control device.[54] Two plants have completely sealed the tanks and control emissions by conservation vents that are exhausted to the atmosphere. Three plants partially cover the top of the tanks with plastic to reduce emissions.[54]

The least effective method of capturing fugitive VOC emissions in the mix room is the use of local ventilation near sources of VOC. Collection hoods may be placed under or suspended over mixers, holding tanks, sinks, and filter changing areas.[54] Separation distances for this equipment can be as great as 3 m (10 ft). To achieve good capture velocities, large airflow rates must be used. Two plants use hoods over the mix equipment and vent to the control device.

4.3.3 Capture of Emissions From Coating Operations

4.3.3.1 Coating Application/Flashoff Capture System. Total enclosures, room ventilation, partial enclosures, local point ventilation, and overhead hoods are used to capture fugitive emissions from the coater. Total enclosures and room ventilation are typically used at new plants because of the improved product quality control that can be achieved by controlling the quality of the air which enters the system.[55]

The most effective emission capture system is a total enclosure. If total enclosures are maintained at a negative pressure, containment is complete because the draft would cause inflow of air through any opening in the enclosure, such as the slit where the film enters. Eight magnetic tape plants have installed total enclosures on coating lines.[54] Two types of total enclosures are used by the magnetic tape industry. One type encloses the entire applicator area, allowing access through doors to the application system. The second type is a smaller, tight-fitting structure around the equipment only. Figure 4-6 illustrates one design of a total enclosure. Typically, ventilation rates are adjusted to avoid concentrations that exceed either the

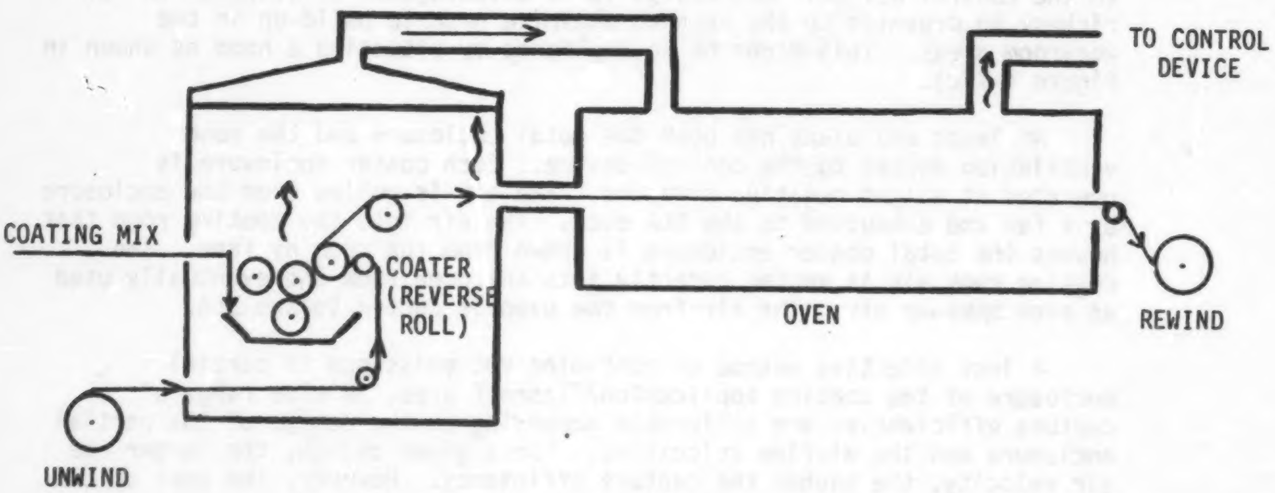
TO CONTROL DEVICE
COATING MIX
COATER (REVERSE ROLL)
OVEN
REWIND
UNWIND

Figure 4-6. Schematic of total enclosure ventilation system.

threshold limit value for occupational exposures or 25 percent of the LEL.[27] At some plants the SLA from the coater head and web enclosure is directed to the drying oven. This reuse of the air reduces the total airflow rate to the control system. At other plants, the exhaust is sent directly to the control device. Total enclosures have been used at some plants for up to 12 years.[56]

In many web coating industries such as magnetic tape, publication rotogravure, and pressure sensitive tapes and labels, the coating room serves as a "total enclosure." At least two magnetic tape plants control the room ventilation air.[54] In such a case, the coating room ventilation air may be directed to a control device [see Figure 4-7(a)]. The cost of such a control scheme can be significantly reduced by recycling the bulk of the coating room ventilation air and withdrawing only a portion for delivery to the control device. For example, as shown in Figure 4-7(b), perhaps only 10 percent of the coating room ventilation air need be directed to the control device; the rest is recirculated. This dramatically reduces the size and cost of the control equipment required. The coating room ventilation air may also be used as oven makeup air, thereby enriching it and further minimizing the total air volume delivered to the control device. Obviously, it is advantageous to withdraw the air richest in organics to the oven to minimize organic build-up in the workroom areas. This might be accomplished by situating a hood as shown in Figure 4-7(c).

At least one plant has both the total enclosure and the room ventilation ducted to the control device. Each coater enclosure is operated at slight negative pressure. The air is pulled from the enclosure by a fan and exhausted to the SLA duct. The air into the coating room that houses the total coater enclosure is drawn from the room by fans. The coating room air is vented directly into the oven room and eventually used as oven make-up air. The air from the oven is ducted to the SLA.

A less effective method of confining VOC emissions is partial enclosure of the coating application/flashoff area. A wide range of capture efficiencies are achievable depending on the design of the partial enclosure and the airflow velocities. For a given design, the larger the air velocity, the higher the capture efficiency. However, the cost of the system and control device (if applicable) are very dependent on the airflow rate, and it becomes uneconomical to operate with large flow rates and high capture efficiencies.

Partial enclosure systems observed at magnetic tape plants consist of flexible vinyl strips hung around the coating application/flashoff area to form a curtain. With these systems, some confinement of fugitive emissions is achieved while ease of access is maintained. The VOC emissions are removed from inside the enclosure by overhead hoods or point ventilation systems.[54] The fugitive emissions so contained can be vented through the drying oven and into the control device although many plants discharge these emissions directly to the atmosphere.[54]

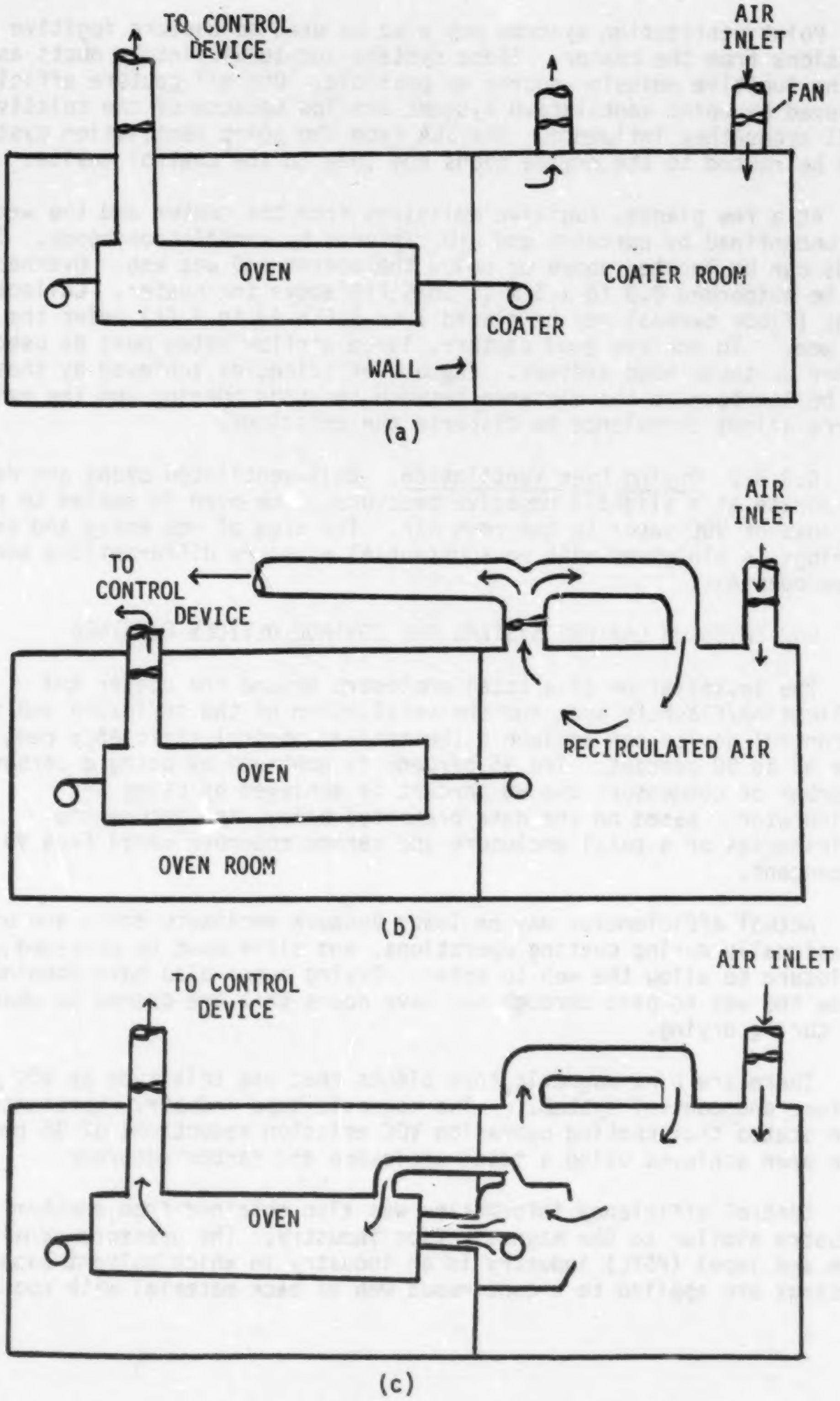
TO CONTROL DEVICE
AIR INLET
FAN
OVEN
COATER ROOM
COATER
WALL
(a)
TO CONTROL DEVICE
AIR INLET
RECIRCULATED AIR
OVEN
OVEN ROOM
(b)
TO CONTROL DEVICE
AIR INLET
OVEN
(c)

Figure 4-7. Schematics of room ventilation systems.

Point ventilation systems may also be used to capture fugitive emissions from the coater. These systems locate air intake ducts as close to the fugitive emission source as possible. Overall capture efficiencies achieved by point ventilation systems are low because of the relatively small areas they influence. The SLA from the point ventilation system may also be routed to the drying ovens and then to the control device.

At a few plants, fugitive emissions from the coater and the wet web are unconfined by curtains and are captured by ventilation hoods. These hoods can be located above or below the coater and wet web. Overhead hoods may be suspended 0.3 to 1.5 m (1 to 5 ft) above the coater. Collection hoods (floor sweeps) may be placed 1 to 1.5 m (3 to 5 ft) under the coater and web. To achieve good capture, large airflow rates must be used with either of these hood systems. Capture efficiencies achieved by these hoods can be low because the distance between the hood opening and the emission source allows turbulence to disperse the emissions.

4.3.3.2 Drying Oven Ventilation. Well-ventilated ovens are designed to operate at a slightly negative pressure. The oven is sealed to prevent any loss of VOC vapor to the room air. The area of web entry and exit openings is minimized with no substantial pressure differentials across these openings.

4.4 VOC EMISSION CAPTURE SYSTEMS AND CONTROL DEVICES COMBINED

The installation of a total enclosure around the coater and application/flashoff area and the ventilation of the enclosure and oven to control device can achieve a theoretical control efficiency ranging from 95 to 98 percent. The 95 percent is achieved by using a carbon adsorber or condenser; the 98 percent is achieved by using an incinerator. Based on the data presented below, the documented efficiencies of a total enclosure and carbon adsorber range from 93 to 95 percent.

Actual efficiencies may be lower because enclosure doors are opened occasionally during coating operations, and slits must be provided in the enclosure to allow the web to enter. Drying ovens also have openings to allow the web to pass through and have doors that are opened to observe the web during drying.

There are nine magnetic tape plants that use this type of VOC emission capture and control system.[54] Two magnetic tape industry representatives have stated that coating operation VOC emission reductions of 95 percent have been achieved using a total enclosure and carbon adsorber.

Control efficiency information was also obtained from another industry similar to the magnetic tape industry. The pressure sensitive tape and label (PSTL) industry is an industry in which solvent-based coatings are applied to a continuous web of back material with coating and drying processes and VOC capture and control systems very similar to those used in the coating of magnetic tape. Typical coatings used in the PSTL industry contain the same weight percent VOC as typical coatings in the magnetic tape industry. The same types of coating applicators and drying ovens are used in both industries. The most common control device in both industries is a fixed-bed carbon adsorber. At one plant tested in the PSTL industry, the building in which the coaters are located is sealed tightly enough to allow a slight negative pressure in the work area relative to the outdoors. The drying ovens operate at a slight negative pressure relative to the room, and the oven make-up air is pulled directly from the coater work area. There are also hoods that are located over the coaters and are vented to the drying ovens. This is a fully enclosed, tight system in which air flows from outdoors into the building, then into the oven, and then to a fixed-bed carbon adsorber. This PSTL facility has demonstrated a 4-week overall VOC emission reduction of 93 percent based on a liquid material balance.[56]

4.5 LOW-SOLVENT TECHNOLOGY

The use of low-solvent coatings such as high solids coatings and waterborne coatings instead of solvent borne coatings is another method of reducing VOC emissions. Research in the areas of low-solvent coatings for magnetic tape continues; however, these technologies are not used in any existing commercial facilities, and no new facilities that incorporate these technologies are planned.[57-60] Conceivably, solvent usage may be reduced through the use of reduced solvent coatings in conjunction with an electron-beam curing process. One vendor predicts that electron-beam curing will eliminate the need for solvent in coatings within the next 2 to 3 years; however, others are less definite about the potential growth of this technology.[61,62] Therefore, coatings involving organic solvents are expected to continue for many years.[57]

A change to either of the two types of low-solvent coatings would result in a decreased airflow through the drying oven. High solids coatings would require less air than conventional coatings to dilute the small amount of solvent to 25 percent of the LEL. The amount of air necessary to dry a waterborne coating depends on the air temperature and relative humidity that is needed to assure product quality; it is unlikely that a waterborne coating would require a higher airflow rate than a conventional solvent borne coating.[63] For the solvents used in this industry, the air volume required to evaporate 3.8 liters (ℓ) (1 gal) of solvent to 25 percent of the LEL ranges from about 230 m^3 (8,000 ft^3) to about 320 m^3 (11,300 ft^3).[64] At 82°C (180°F), the amount of air needed to evaporate 3.8 ℓ (1 gal) of water to a relative humidity of 25 percent and 7 percent is about 54 m^3 (1,900 ft^3) and 300 m^3 (10,700 ft^3), respectively.[64] Thus, because airflow rate is the major design parameter, a fixed-bed carbon adsorber used to control emissions from a line applying low-solvent coatings would be no larger than that for solvent borne lines.

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5. MODIFICATION AND RECONSTRUCTION

Standards of performance apply to facilities for which construction, modification, or reconstruction commenced (as defined under 40 CFR 60.2) after the date of proposal of the standards. Such facilities are termed "affected facilities." Standards of performance are not applicable to "existing facilities" (i.e., facilities for which construction, modification, or reconstruction commenced on or before the date of proposal of the standards). An existing facility may become an affected facility and, therefore, be subject to the standard of performance if the facility undergoes modification or reconstruction.

Modification and reconstruction are defined under 40 CFR 60.14 and 60.15, respectively. These general provisions are summarized in Section 5.1. Section 5.2 discusses the applicability of these provisions to magnetic tape manufacturing facilities.

5.1 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 Modification

With certain exceptions, any physical or operational change to an existing facility that would increase the emission rate to the atmosphere from that facility of any pollutant covered by the standard would be considered a modification within the meaning of Section 111 of the Clean Air Act. The key to determining if a change is considered a modification is whether actual emissions to the atmosphere from the facility have increased on a mass per time basis (kg/h [lb/h]) as a result of the change. Changes in emission rate may be determined by the use of emission factors, by material balances, by continuous monitoring data, or by manual emission tests in cases where the use of emission factors does not clearly demonstrate that emissions do or do not increase. Under the current regulations, an emission increase from one facility may not be offset with a similar emission decrease at another facility to avoid becoming subject to new source performance standards (NSPS). If an existing facility is determined to be modified, it becomes an affected facility, subject to the standards of performance for the pollutant or pollutants that have increased due to modification. All emissions, not just the incremental increase in emissions, of the pollutants that have increased from the facility must be in compliance with the applicable standards. A modification to one existing facility at a plant will not cause other existing facilities at the same plant to become subject to the standards.

Under the regulations, certain physical or operational changes are not considered to be modifications even though emissions may increase as a result of the change (see 40 CFR 60.14(e)). For the most part, these exceptions are allowed because they account for fluctuations in emissions that do not cause a facility to become a significant new source of air pollution. The exceptions as allowed under 40 CFR 60.14(e) are as follows:

1. Routine maintenance, repair, and replacement (e.g., lubrication of mechanical equipment; replacement of pumps, motors, and piping; cleaning of equipment);

2. An increase in the hours of operation;

3. Use of an alternative fuel or raw material if, prior to proposal of the standard, the existing facility was designed to accommodate that alternate fuel or raw material;

4. The addition or use of any system or device whose primary function is to reduce air pollutants, except when an emission control system is replaced by a system determined by the EPA to be less environmentally beneficial;

5. Relocation or change in ownership of the existing facility; and

6. An increase in the production rate without a capital expenditure. A capital expenditure is defined in 40 CFR 60.2 as an expenditure for a physical or operational change to an existing facility which exceeds the product of (1) the applicable "annual asset guideline repair allowance percentage" specified in the latest edition of Internal Revenue Service (IRS) Publication 534 and (2) the existing facility's basis (fixed capital cost), as defined by Section 1012 of the Internal Revenue Code. However, the total expenditure for a physical or operational change to an existing facility must not be reduced by any "excluded additions" as defined in IRS Publication 534, as would be done for tax purposes. For the magnetic tape industry, the asset guideline repair allowance is 15 percent as defined under Asset Guideline Class 26.2--Manufacture of Converted Paper, Paperboard, and Pulp Products, which includes paper coating.[1]

An owner or operator of an existing facility who is planning a physical or operational change that may increase the emission rate of a pollutant to which a standard applies shall notify the appropriate EPA regional office 60 days prior to the change, as specified in 40 CFR 60.7(a)(4).

5.1.2 Reconstruction

An existing facility may become subject to NSPS if it is reconstructed. Reconstruction is defined as the replacement of the components of an existing facility to the extent that (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost required to construct a comparable new facility, and (2) it is technically and economically feasible for the facility to meet the applicable standards. Because the EPA considers reconstructed facilities to constitute new construction rather than modification, reconstruction determinations are made irrespective of changes in emission rates.

The purpose of the reconstruction provisions is to discourage the perpetuation of an existing facility for the sole purpose of circumventing a standard that is applicable to new facilities. Without such a provision, all but vestigial components (such as frames, housing, and support structures) of the existing facility could be replaced without causing the facility to be considered a "new" facility subject to NSPS. If the facility is determined to be reconstructed, it must comply with all of the provisions of the standards of performance applicable to that facility.

If an owner or operator of an existing facility is planning to replace components, and the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost of a comparable new facility, the owner or operator must notify the appropriate EPA regional office 60 days before the construction of the replacement commences, as required under 40 CFR 60.15(d).

5.2 APPLICATION TO MAGNETIC TAPE MANUFACTURING FACILITIES

5.2.1 Modification

5.2.1.1 Solvent Storage Tanks. Few, if any, changes in the physical configuration of storage tanks that would increase emissions are anticipated. Because replacement of frames, housings, and supporting structures would not increase emissions from a storage tank, such replacement would not constitute a modification. Increasing emissions by increasing solvent throughput would not be considered a modification because no capital expenditure would be associated with the increased throughput. The addition of a tank to a coating line without a corresponding increase in line solvent use would not be a modification because the VOC emissions from such an addition would only increase overall emissions from the coating line by <0.05 percent. Thus, few, if any, modifications of solvent storage tanks are expected.

5.2.1.2 Coating Mix Preparation Equipment. No changes in the physical configuration of coating mix preparation equipment that would increase emissions are expected. Mixers, mills, and tanks are used indefinitely and repaired as needed except for replacement to achieve process changes.[2] These repairs would not result in increased VOC emissions. The addition of pieces of mix equipment without a corresponding increase in solvent use would not be considered a modification. Such an addition might change the relative emissions from the mix room and coating operation, but the total emissions from the coating line would not increase. The addition of mix equipment with increased throughput for increased production may be considered a modification, depending on the capital cost of such an addition.

Because of the large variations in the types, sizes, and, thus, cost of mix room equipment used in the magnetic tape coating industry, it would be necessary to determine if the capital cost of any modification to the mix room is greater than 15 percent of the existing facility's capital cost on a case-by-case basis.

Operational changes that might increase VOC emissions would be a change in the length of time required to prepare coating mixtures or a change in the raw materials. A change in processing time would not constitute a modification, however, because it would be an increase in hours of operation, which is exempted under 40 CFR 60.14(e) from modification determinations. A change in raw materials processed would only be considered a modification if the mix equipment were not designed to accommodate the new raw materials before proposal of the standard. For example, if the new raw materials chemically react with the materials used to construct the mix equipment, it could be considered that the mix equipment was not designed to accommodate the new raw materials. However, the same coating mix preparation equipment is used to prepare the known range of commercial coatings for audio, video, and computer tape products.[3] Thus, modifications of coating mix equipment are not expected.

5.2.1.3 Coating Operation. Potential modifications of magnetic tape coating operations and processes include changes to increase production and changes in the method of applying the magnetic coating mixture to the plastic film. Changes in the application method could increase the VOC emission rate of the coating operation if the new method applied thicker coatings or coatings with a higher solvent content. If these changes can be accomplished with the existing coater, these changes would not be considered modifications. If these changes require the installation of a new coater, the cost may be large enough to be considered a modification. However, the trend in this industry is towards thinner coatings.

Production increases can also increase the VOC emission rate from a coating operation. The productivity of a magnetic tape coating operation is determined by the web width, the line speed, the hours of operation, and the efficiency of scheduling. Production increases can be accomplished by two methods. In the first method, the operation of the existing equipment is pushed to its capacity by removal of bottlenecks, more efficient scheduling, and increasing the hours of operation. When no more capacity can be achieved in this manner, new coating operations are built or existing operations are upgraded. Most of the production increases (and the associated emission increases) from the first method are specifically exempted from NSPS compliance under 40 CFR 60.14(e). Most of the equipment modifications in the second method involve totally new sources or investments so large as to qualify as reconstruction. Specific examples of production equipment changes are discussed below with emphasis on the few cases where the modification clause might apply.

5.2.1.3.1 Changes in web width. Changes in the width of web would increase both production and emissions. The maximum web width that any given coating line can accommodate is an integral part of the basic design of the system. Web width cannot be increased significantly (<2.5 cm [<1 inch]) beyond this maximum without installing essentially all new equipment. It is, therefore, unlikely that such a modification would be made.

5.2.1.3.2 Changes in line speed. An increase in maximum line speed is the most likely change that could constitute a modification. The maximum line speed for a given facility depends on both the basic design of the coating line and on the specifications for each product. The factors that might constitute a line speed limitation include:

1. A limitation on the available power and/or speed of the motors that drive the web;

2. Drying limitations based either on the amount of heat available or on residence time in the oven;

3. A limitation on air circulation in the drying oven that causes the lower explosive limit (LEL) to be exceeded; and

4. A limitation on the maximum speed at which a smooth coating can be achieved with a given coating head or at which the line can be operated without shutdowns.

Any equipment changes made to increase production rate (such as larger/faster drive motors, larger ovens, higher capacity boilers for the ovens, higher capacity oven air circulating blowers, or LEL sensors with alarm/shutdown capacity) would result in increased emissions. Thus, the facility could come under the modification provisions provided the capital cost is greater than 15 percent of initial capital cost of the existing facility and, therefore, is a capital expenditure according to the definition in 40 CFR 60.2. The cost of increasing the line speed ranges from 2 to 27 percent of the fixed capital cost of an existing facility.[4-6] In general, the cost required to double the line speed of a 26-inch line will result in a capital cost greater than 15 percent of the basis and, thus, will cause the facility to become subject to the modification provisions.

5.2.1.3.3 Raw material changes. Many changes in coating mixture specifications (such as percent VOC or coating thickness) could also result in increased VOC emissions. Such changes would only be considered modifications if the coating operation equipment were not designed to accommodate use of that coating mix.

5.2.1.3.4 Changes in the hours available for operation and/or scheduling efficiency. A typical magnetic tape coating operation operates from approximately 100 to 168 hours per week.[7,8] Significant increases in production and emissions could result from extending the working hours, but this is specifically exempted under the modification clause.

Even during the hours of operation, a coating operation may be shut down to change products. Each time a change is made in the type of tape to be coated on a given line, time must be allowed to clean up the equipment and to reset the controls to the new product specifications. Thus, careful scheduling can increase production, which will result in increased VOC emissions. The careful scheduling of production would not be considered a modification if that production rate increase can be accomplished without a capital expenditure.

5.2.2 Reconstruction

Reconstruction, as defined under 40 CFR 60.15, might occur if the components of a magnetic tape manufacturing facility (i.e., storage tanks, mix equipment, coating operation, and other miscellaneous sources) are replaced and if the fixed capital costs of the replacement components exceed 50 percent of the fixed capital costs of a comparable new facility.

Only under catastrophic circumstances (e.g., total destruction of the storage tank by fire, or explosion, or collapse of the roof) would a facility possibly become subject to the NSPS reconstruction provision due to physical changes in the solvent storage tank; however, this cost relative to that of the entire facility may not be large enough. Because associated support structures (frames, housing, etc.) are not part of a tank, replacement of such structures would not constitute reconstruction.

Replacement of mix preparation equipment may occasionally incur sufficient expense to qualify as reconstruction of the entire facility if the replacement is extensive in a large mix room. Replacement of single components in a coating operation (i.e., a change in coating applicator or drying oven) occurs only rarely. However, the replacement of the entire coater could be sufficiently expensive to qualify as a reconstruction.[9,10] Some of the equipment changes discussed in Section 5.2.1.3 may incur sufficient cost to qualify as reconstructions. Any change of equipment to increase web width significantly would probably require such extensive equipment replacement that it would be considered a reconstruction. Such changes are unlikely since the plant probably could install a new coating operation for approximately the same expenditure. Similarly, equipment changes to increase line speed significantly could be costly enough to require a reconstruction determination. However, it is very unlikely that the line speed would be increased to a speed such that the capital cost would be greater than 50 percent of the existing facility's fixed capital cost. Increasing the line speed to highest known existing speed of 1,000 feet per minute represents only 27 percent of the capital cost of an existing facility.[6,8] Reconstruction in the magnetic tape manufacturing industry is expected to occur only in isolated cases, if at all.

5.3 REFERENCES FOR CHAPTER 5

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6. MODEL LINES AND REGULATORY ALTERNATIVES

6.1 GENERAL

The purpose of this chapter is to define the model lines and to present the regulatory alternatives that can be applied to them. Model lines are parametric descriptions of typical lines that will be encountered in new, modified, or reconstructed plants. For this study, parametric descriptions of typical lines are presented for the solvent storage tanks, the coating mix preparation room (mix room), and the magnetic tape coating operation. For systems that have more than one coating operation in series, each coating operation will be considered a single unit operation. A model line consists of the combination of model solvent storage tanks, a model mix room, and a model coating operation. Model line parameters are defined for lines of three different sizes and represent control of volatile organic compound (VOC) emissions from newly constructed magnetic tape coating plants by add-on control systems, such as fixed-bed carbon adsorbers. Model lines representing the use of process modifications, such as waterborne coatings, are not analyzed because the use of such process modifications is not demonstrated at the commercial level. (See Chapter 3 for descriptions of solvent storage, coating mix preparation, and tape coating operations and Chapter 4 for descriptions of control devices and control configurations.)

The regulatory alternatives represent various courses of action that the U.S. Environmental Protection Agency (EPA) could take in controlling VOC emissions from magnetic tape manufacturing plants. The environmental, energy, and economic impacts associated with the application of the alternatives to each of the model lines are presented in subsequent chapters.

6.2 MODEL LINES

Three model line sizes (research, small, and typical) have been selected to characterize the manufacturing and research coating lines expected to be constructed, modified, or reconstructed in the near future. Figure 6-1 presents a schematic of a typical controlled plant with solvent storage tanks, coating mix preparation equipment, and a coating operation. Model solvent storage tanks are defined as the number and size of tanks required to supply solvent to the model mix room to be used in the coating preparation. Throughout this chapter, model storage tank refers to these groups of tanks, not individual tanks. A model mix room is defined as the mix equipment (i.e., mills, mixers, polishing tanks, and holding tanks) required to supply coating to the magnetic tape coating operation. A model coating operation is defined as the combination of a coating application/flashoff area, a drying oven, and the necessary ancillary equipment. The model coating operation is defined as a single coating operation because new plants are expected to be constructed with one coating operation plus sufficient space to add additional coating operations in the future, and existing plants are expected to expand capacity by addition of only one coating operation at a time.

Separate model lines are not specified for production of audio, video, and computer tape products because (1) any coating line can be used to produce all types of tape products and (2) the range of solvent content of coatings, coating thickness, and oven exhaust rates observed does not vary with the type of tape being produced.[1] Thus, VOC emissions do not vary as a function of product type, and separate model lines are not required to evaluate the control equipment costs and cost effectiveness of the regulatory alternatives.

The control of VOC emissions from the model storage tank and model mix room is based on either the use of equipment designed to reduce breathing (thermal) losses or diffusion losses of solvent, or the use of VOC capture devices combined with solvent recovery systems. Model coating operations are assumed to be controlled by solvent vapor capture devices combined with a solvent recovery system (carbon adsorber or condenser) or a solvent destruction device (incinerator).

Land and utility requirements for the model lines are shown in Table 6-1. Additional building area is required for slitting, packaging, and testing the magnetic tape as well as for administrative offices and laboratory facilities.

Utilities for the model lines consist of electricity, steam, water, and natural gas. The lines use electricity to operate the motors for the mixers, mills, pumps, coating lines, and fans. In the model lines, the ovens are assumed to be indirectly heated by steam produced by a natural gas-fired boiler. Carbon adsorbers use steam for regeneration of the carbon beds and water for cooling and condensing the steam. Incinerators used for some of the regulatory alternatives are assumed to use natural gas.

6.3 MODEL LINE PARAMETERS

The model line parameters are given separately for the model storage tank, model mix room, and the model coating operations in Tables 6-2 through 6-6. The model line parameters are based on specific information from magnetic tape plants and general information from various industry contacts.

The raw materials used in magnetic tape manufacturing are polyester film, solvents, magnetic particles, binder (generally polyurethanes), dispersants, lubricants, conductive pigments, and miscellaneous additives.

The major design parameters for the model lines are the production rate, hours of operation, coating solvent content, and coating thickness. Combined, these parameters determine the potential uncontrolled VOC emission rate from the solvent storage tanks, the mix room, and the coating operation. These parameters, and others, also determine the design specifications of the control device for the model line. The basis of the assumed parameters is discussed below.

6.3.1 Solvent Storage Tanks

The model storage tanks described in Table 6-2 are defined as the size and number of tanks required to supply solvent to the model mix room. The number of storage tanks is the same as the number of different solvents used in the industry. The sizes of the storage tanks are based on the most common sizes used in the industry. Uncontrolled VOC emission levels are based on equations developed by the American Petroleum Institute.[2] Emissions may be controlled by installing conservation vents, by ducting the emissions to a disposable canister carbon adsorber, or by ducting the emissions to the same carbon adsorber controlling emissions from the coating operation. The conservation vents have an average control efficiency of 35 percent and the adsorption control methods would reduce emissions by 95 percent.

6.3.2 Mix Room Equipment

The model mix rooms described in Table 6-3 are defined as the total mix equipment (mills, mixers, polishing tanks, and holding tanks) that supplies coating to the model coating operations. The assumed number of mills, mixers, polishing tanks, and holding tanks (see Table 6-3) is based on a reasonable minimum number of equipment items that could be used per coating operation. Because considerable variation in equipment used for coating mix preparation exists among magnetic tape lines, the assumed model mix room equipment represents only one scenario of possible combinations of equipment used in this area. The ventilation rate of the equipment is based on test data from one company.[3] Uncontrolled VOC emission levels for the model mix rooms are based on calculated solvent usage for the model coating operations. (The coating formulation is discussed under coating operation because of the effect of solvent concentration and composition on the design parameters of the control device.)

Emissions from mix equipment may be controlled by sealing this equipment with covers. To prevent excessive pressure buildup, these covers would be equipped with conservation vents. Sealing mix equipment with this type of cover would reduce emissions from mix equipment by at least 40 percent.

A more stringent level of control could be achieved through a combination of sealed covers, ductwork, and a carbon adsorber. The sealed cover and ductwork would capture the emissions and route them to a carbon adsorber that prevents their release to the atmosphere. Such a system would reduce emissions from mix equipment by 95 percent.

6.3.3 Coating Operation

The model coating operation parameters are defined in Tables 6-4 to 6-6. The basis of the parameters is discussed below.

6.3.3.1 Capture and Control Device Application. The VOC capture devices used on the coating application/flashoff area of the coating operation at magnetic tape lines are (in order of decreasing capture efficiency) total enclosures, partial enclosures, and exhaust hood ventilation systems (see Chapter 4 for descriptions and discussion).

The control devices used on the coating operation are primarily carbon adsorbers, incinerators, and condensers. Carbon adsorbers and incinerators are used to control VOC emissions from the drying oven and varying amounts of the application/flashoff area emissions (depending on the type of fugitive emission capture device). There are two types of condensers presently in use in this industry, one using an air atmosphere (System 1 in Tables 6-5 and 6-6) and one using an inert (nitrogen) atmosphere (System 2 in Tables 6-5 and 6-6). Both systems are currently used to control emissions only from drying ovens, although systems could be designed to allow control of the application/flashoff area in addition to the drying oven. Oven ventilation rates and solvent formulations at lines utilizing condensers are significantly different from those used at plants with carbon adsorbers or incinerators to achieve cost-effective control. Therefore, model coating operation parameters are provided for carbon adsorbers/incinerators and for the two condensers.

6.3.3.2 Size. Three sizes of model tape coating lines have been developed: (1) 0.15-m-wide (6-inch-wide) coater for research, which is operated for approximately 2,000 hours per year and may use a blend of any of five solvents used by the industry; (2) a 0.15-m-wide (6-inch-wide) coater for tape production, which is operated for approximately 6,000 hours per year; and (3) a 0.66-m-wide (26-inch-wide) coater for tape production, which is also operated for approximately 6,000 hours per year. The various model sizes were selected to characterize manufacturing and research coating lines expected to be constructed, modified, or reconstructed in the near future. The line speeds are typical for new coaters of these sizes. Other web widths and line speeds are now used, but they are not considered representative of new research or manufacturing lines.

6.3.3.3 Coating Thickness and Formulation. The thickness of the wet coating is the average of the values reported by the industry. The percent VOC in the coating and the coating density are representative values of coating formulations used to produce audio, video, and computer tape products. The solvent mixture of tetrahydrofuran (THF), toluene, and cyclohexanone was selected to be the coating formulation for small and typical model coating operations controlled by carbon adsorbers or incinerators because (1) these devices are used primarily to control VOC emissions at lines using a mixture of several solvents and (2) the majority of the known coating formulations with multiple solvents contain THF, toluene, and from one to three ketones. Cyclohexanone was selected as the ketone used by the model line because it is commonly used and results in slightly greater operating costs due to carbon bed fouling. For the research model line, five solvents (THF, toluene, cyclohexanone, methyl ethyl ketone, and methyl isobutyl ketone) were selected for use in the coating formulations.

Two coating solvent formulations for condenser control systems are used in the analysis of control costs: (1) 100 percent cyclohexanone and (2) the solvent mixtures used for the carbon adsorber controlled model lines. Existing magnetic tape coating plants using condensation solvent recovery systems use 100 percent cyclohexanone as the coating solvent base. Therefore, to estimate control costs representative of those incurred by industry, 100 percent cyclohexanone was selected as the solvent for one group of model lines with condenser (Table 6-4). To consider the possibility of future situations where the use of other solvents may be necessary and to allow comparison of costs with those incurred using a carbon adsorber to recover blends of solvents, the solvent mixtures used for the carbon adsorber model lines are also used to characterize costs for model lines with condensers (Table 6-6).

6.3.3.4 Coating Application/Flashoff Area and Drying Oven Ventilation Rates. The ventilation rates for drying ovens were calculated using the procedures specified in the design manual Ovens and Furnaces.[5] For model coating operations using carbon adsorbers or incinerators, the drying oven exhaust rate was calculated for the solvent mixture and for usage rates assuming operation of the oven at 25 percent of the lower explosive limit (LEL) of the solvents. Even though modern ovens can be designed to operate safely at 50 percent of the LEL, the higher dilution factor (lower percentage of the LEL) was selected for the model coating operation parameters because (1) many plants operate drying ovens at around 25 percent of the LEL, (2) it maximizes air flow rates and costs, and (3) a rough cost analysis indicated that worst-case control costs (i.e., incinerator controlled coating operation) were only approximately $600 per ton at 25 percent of the LEL. The calculated ventilation rates are within the range of oven ventilation rates reported by the magnetic tape manufacturing industry.

For model coating operations using condensers, the drying oven exhaust rate was calculated for the solvent usage rate assuming (1) operation of the oven at 40 percent of the LEL for the condenser using air atmosphere (System 1 in Tables 6-4 and 6-5) and (2) operation of the oven at 10 percent by volume VOC for the condenser using inert (nitrogen) atmosphere (System 2 in Tables 6-4 and 6-5). These solvent vapor concentrations are representative of the operating conditions for ovens controlled by the two types of condensers used in this industry. Higher solvent vapor concentrations are used by the two condensers to reduce operating costs and increase solvent recovery efficiency.

Ventilation rates for the coating application/flashoff area are given for total and partial enclosures. The ventilation rates for the total enclosures are based on flow rates used by the industry in comparable-sized total enclosures. The ventilation rates for the partial enclosures are calculated using the ACGIH recommended calculation procedure for booth hoods (i.e., hood with one open face).[6] These flow rates are similar to ventilation rates reported by the industry for hoods. For carbon adsorber, condenser, and incinerator control devices, it is assumed that the effluent from the total and partial enclosures (when applicable) is directed into the oven and, therefore, eventually vented through the control device. This is the approach used in many existing plants in the magnetic tape coating industry.

6.3.3.5 Uncontrolled Emission Rate. The uncontrolled VOC emission rates for the model coating operations are the potential emissions resulting from evaporation of the total solvent usage required for the production rates specified for the model coating operation. The uncontrolled VOC emission levels do not include VOC emissions that result from cleaning of equipment. Solvent used for cleaning represents approximately 6 percent of the total solvent usage by a magnetic tape manufacturing plant.[7] Most of this solvent stays in the liquid phase and can be reused or disposed of in accordance with applicable solid waste and water quality regulations.[8] Thus, equipment cleaning will increase the emission levels by much less than 6 percent.

6.4 REGULATORY ALTERNATIVES

A set of control options was developed for each of the three emission sources (solvent storage tanks, mix room, and coating operation), and these options are presented in Tables 6-7, 6-8, and 6-9. These control options represent the various emission control levels that are achievable based on available emission control techniques.

Because there are no magnetic tape plants with only one coating line and at which only the coating application/flashoff area and the drying oven emissions are controlled, no emission test data are available from this industry on control levels for individual emission sources. Engineering judgment, statements from industry representatives, and test data from related industries support the percent control levels assigned to the control options. Control option 2A for the coating operation (see Table 6-9), has a control efficiency of 87 percent that is based on the use of a partial enclosure that captures at least 50 percent of the VOC emissions from the coating application/flashoff area. Partial enclosures have been measured to achieve capture efficiencies of greater than 80 percent on flexible vinyl coating and printing operations and publication rotogravure coating operations.[9,10] Partial enclosures on magnetic tape coating operations should be capable of achieving similar capture efficiencies. For coating operation control option 3A, the control efficiency of 93 percent is based on the use of a total enclosure and a carbon adsorber to capture and control emissions. At a pressure-sensitive tape and label plant (PSTL) with a room ventilation system around the coater (a type of total enclosure) and a fixed-bed carbon adsorber, a control efficiency of 93 percent was determined by a 4-week liquid solvent material balance.[11] Because of the strong similarities in processes and in the capture and control systems, it is judged that a magnetic tape line would be able to achieve a control efficiency similar to that achieved by the tested PSTL plant.

The control options in Tables 6-7, 6-8, and 6-9 were combined to form the regulatory alternatives for a magnetic tape coating line. The regulatory alternatives with the associated emission capture and control device configurations are presented in Table 6-10. The regulatory alternatives include only the conservation vent control options for solvent storage tanks. Although considerable research effort is ongoing in development of waterborne coatings and electron-beam-cured resins, which can be applied without the use of solvents, neither of these technologies has been demonstrated at the commercial level.[12,13] Therefore, the regulatory alternatives are based only on add-on controls.

For the analysis of the control levels achievable, it is assumed that 90 percent of the emissions are from the coating operation and that less than 10 percent are from the mix equipment.[14] Emission test data from two magnetic tape plants and estimates from manufacturers were used to apportion emissions from the coating operation. These data and estimates indicate that the oven is the source of 90 percent of the emissions from the coating operation, and the application area is the source of the remaining 10 percent.[15]

The control levels assigned to the regulatory alternatives are calculated using the estimated emission rates, capture device efficiencies, and control device efficiencies. Because of uncertainties in the efficiencies of capture devices and the apportionment of emissions between the oven and the application/flashoff area, the level of control has been reduced by 2 to 3 percent from the calculated theoretical value. The control level of the storage tanks is included in the calculation of overall line efficiency; however, the effect on the control level is lost when the numbers are rounded to the nearest whole percent.

Table 6-11 presents a summary of the assumptions and methods used to calculate the control efficiencies for the control of either the mix room or the coating operation; the control levels for the remaining regulatory alternatives are the sum of the control levels for the respective combinations of these two emission sources. The emission levels for the regulatory alternatives are intended to cover a range from baseline to successively more stringent control so that a range of potential impacts can be considered in selecting regulatory alternatives on which to base a new source performance standard (NSPS).

Regulatory Alternatives I and IV represent the baselines, the levels of control that would be experienced in the absence of an NSPS, for plants located in ozone attainment and nonattainment areas, respectively. Regulatory Alternatives V, VIII, and X are based on control of only the coating operation (application/flashoff area and drying oven) and storage tanks. Regulatory Alternatives II and III are based on control of emissions from the mix room equipment and storage tanks only. Regulatory Alternatives VI, VII, IX, and XIA through XIV represent various combinations of control levels achievable by control of the storage tanks, mix room equipment, and the coating operation.

Alternative I represents uncontrolled storage tanks, mix rooms, and coating operations in magnetic tape coating lines and is the level of control presently required of plants located in ozone attainment areas. Alternative IV corresponds to the Control Techniques Guideline (CTG) requirement of 0.35 kg VOC/liter of coating (2.9 lb VOC per gallon of coating) for existing paper coating plants (this category includes magnetic tape coating) and is based on application of reasonably available control technology (RACT) to magnetic tape coating lines. The 75 percent control level of Alternative IV can be achieved by capturing all drying oven emissions and by venting all of these emissions to a control device that achieves 95 percent VOC control.

Alternatives II and III represent control levels achievable from control of mix room equipment alone. Alternative II represents the estimated control level achievable by placing sealed, vapor-tight covers on the individual mills, mixers, and holding tanks and venting each of these to the atmosphere through conservation vents. This control approach is used in at least two magnetic tape coating plants.[16,17] The level of control represented by Alternative III is achievable by placing sealed covers on the individual equipment and venting the emissions to a control device that is 95 percent efficient. At least seven magnetic tape coating plants are known to control emissions from the mix preparation equipment by this approach.[18-20]

Alternative V is based on control of all emissions from the drying oven and part of the emissions from the application/flashoff area. This control level can be achieved by capturing approximately 95 percent of all VOC emissions from the coating operation (application/flashoff area and drying oven) and by venting all of these emissions through a control device that achieves 95 percent control efficiency. This combination results in an overall level of control of about 78 percent. The required capture efficiency can be achieved by use of a partial enclosure to collect emissions from the coating application/flashoff area in addition to use of an efficient oven ventilation system.

Alternatives VIII and X are based on essentially complete capture of all emissions from the coating operation (approximately 90 percent of total emissions from the coating operation and the mix room) and control of these emissions by either a 95 or 98 percent efficient control device. This configuration results in an 83 percent control level for Alternative VIII (95 percent control of approximately 90 percent of the emissions). Similarly, for Alternative X the 85 percent level of control results from using the same capture efficiencies as in Alternative VIII and a 98 percent control efficiency. Complete capture of coating operation (application/flashoff area and drying oven) emissions can be achieved by use of a total enclosure around the coating operation.

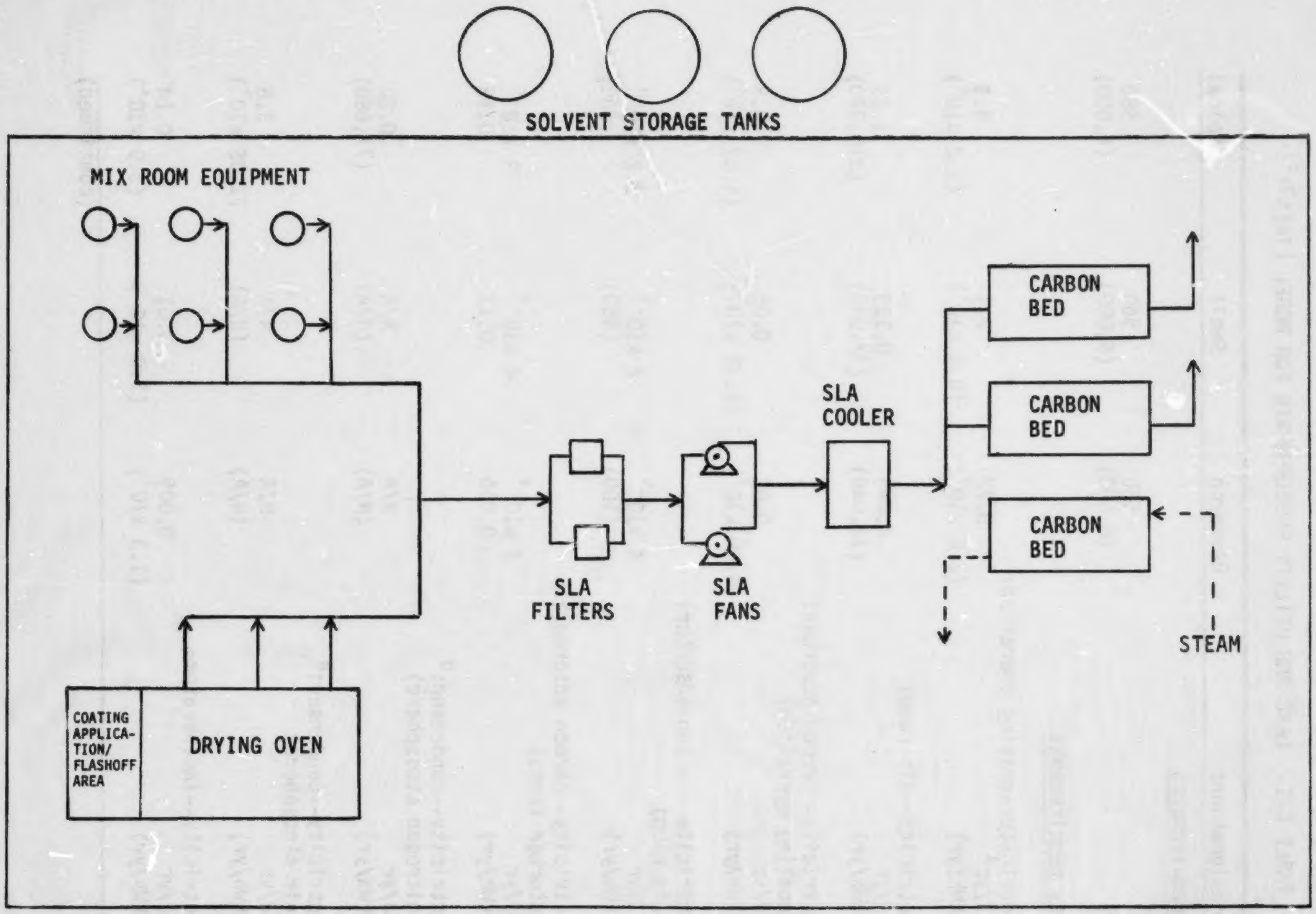
SOLVENT STORAGE TANKS
MIX ROOM EQUIPMENT
COATING APPLICATION/FLASHOFF AREA
DRYING OVEN
SLA FILTERS
SLA FANS
SLA COOLER
CARBON BED
CARBON BED
CARBON BED
STEAM

Figure 6-1. Schematic of coating operation with VOC capture device and fixed-bed carbon adsorption system.

TABLE 6-1. LAND AND UTILITY REQUIREMENTS FOR MODEL LINES[a,21]

Line designation:	Research	Small	Typical
Land requirements			
m^2	560	560	560
(ft^2)	(6,000)	(6,000)	(6,000)
Utility requirements			
Electricity--coating operation:			
TJ/yr[a]	0.72	2.1	4.3
(kWh/yr)	(2.0×10^{5})	(6.0×10^{5})	(1.2×10^{6})
Electricity--mix room:			
TJ/yr	0.043	0.133	1.33
(kWh/yr)	(12,040)	(37,040)	(370,370)
Electricity--carbon adsorber: (coating operation)			
TJ/yr	0.02	0.05	0.5
(kWh/yr)	(4.40×10^{3})	(1.32×10^{4})	(1.32×10^{5})
Electricity--carbon adsorber: (mix room)			
TJ/yr	4×10^{-4}	2×10^{-3}	2.2×10^{-3}
(kWh/yr)	(100)	(450)	(600)
Electricity--carbon adsorber: (storage tanks)			
TJ/yr	2×10^{-7}	4×10^{-7}	3×10^{-6}
(kWh/yr)	0.066	0.11	0.95
Electricity--condenser:[b] (nitrogen atmosphere)			
TJ/yr	N/A	N/A	0.28
(kWh/yr)	(N/A)	(N/A)	(77,680)
Electricity--condenser:[b] (air atmosphere)			
TJ/yr	N/A	N/A	3.8
(kWh/yr)	(N/A)	(N/A)	(1.05×10^{6})
Electricity--incinerator:			
TJ/yr	0.005	0.01	0.14
(kWh/yr)	(1.3×10^{3})	(3.9×10^{3})	(3.9×10^{4})

(continued)

TABLE 6-1. (continued)

Line designation:	Research	Small	Typical
Steam--ovens:			
Tons/yr[c]	340	1,010	1,010
(1,000 lb/yr)	(740)	(2,220)	(2,220)
Steam--carbon adsorber: (coating operation)			
Tons/yr[c]	90	270	2,550
(1,000 lb/yr)	(200)	(600)	(5,600)
Steam--carbon adsorber: (mix room)			
Tons/yr[c]	11	29	284
(1,000 lb/yr)	(24)	(64)	(624)
Steam--carbon adsorber: (storage tanks)			
Tons/yr	0.146	0.182	1.55
(1,000 lb/yr)	(0.320)	(0.400)	(3.4)
Cooling water--carbon adsorber: (coating operation)			
m^3/yr	90	270	2,550
(1,000 gal/yr)	(24)	(72)	(672)
Cooling water--carbon adsorber: (mix room)			
m^3/yr	11.4	30.3	284
(1,000 gal/yr)	(3)	(8)	(75)
Cooling water--carbon adsorber: (storage tanks)			
m^3/yr	0.015	0.182	1.56
(1,000 gal/yr)	(0.004)	(0.048)	(0.413)
Natural gas--incinerator:			
TJ/yr	0.50	1.75	15.0
(10^6 ft^3/yr)	(0.772)	(2.316)	(23.16)

[a] TJ = Terajoules = 10^{12} joule = 2.78 $\times 10^{-7}$ kWh.

[b] Condensation systems cannot be designed for research and small size lines.

[c] Metric ton = 1,000 kilograms.

TABLE 6-2. MODEL SOLVENT STORAGE TANK PARAMETERS

Line designation:	Research	Small	Typical
Solvent usage, m^3/yr (gal/yr)	23 (6,130)	70 (18,400)	700 (184,000)
No. of different solvents used	5	3	3
No. of storage tanks	5	3	3
Capacity of each tank, m^3 (gal)	4 (1,000)	4 (1,000)	40 (10,000)
Emissions, Mg/yr (tons/yr)	0.03 (0.03)	0.05 (0.05)	0.39 (0.43)

TABLE 6-3. MODEL MIX ROOM PARAMETERS

Line designation:	Research	Small	Typical	Ref
1. Line information Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)	3
Line speed, m/s (ft/min)	1.3 (250)	1.3 (250)	2.5 (500)	3
Operating h/yr	2,000	6,000	6,000	4
2. Mix room information				
Coating prepared, m^3/d (gal/d)	0.13 (35)	0.26 (70)	2.6 (675)	5
Solvent used, m^3/day (gal/d)	0.11 (30)	0.21 (55)	2.1 (550)	5
Equipment, number of				
Mixers	2	2	2	
Mills[a]	1	1	1	
Holding tanks	1	2	2	
Polishing tanks	1	2	2	
Equipment ventilation rate per item,[b] m^3/h (acfh)	5.7 (200)	5.7 (200)	5.7 (200)	
Uncontrolled VOC emissions, Mg/yr (tons/yr)	2.7 3	7.3 8	71 78	5

[a] VOC emissions from working losses in sealed mills will be pushed into the next tank and subsequently controlled by that tank's control device.

[b] For systems purging tanks and ducting emissions to control device.

TABLE 6-4. MODEL COATING OPERATION PARAMETERS FOR CARBON ADSORBER OR INCINERATOR CONTROL OPTIONS

Line designation:	Research	Small	Typical	Ref.
1. Line information				
Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)	22
Line speed, m/s (ft/min)	1.3 (250)	1.3 (250)	2.5 (500)	22
Operating h/yr	2,000	6,000	6,000	
2. Process information				
Coating thickness, wet, μm[a] (mil)[b]	25 (1)	25 (1)	25 (1)	22
Coating formulation:				
% VOC, weight	63	63	63	22
% VOC, volume	80	80	80	22
Density, kg/m^3 (lb/gal)	1,200 (10)	1,200 (10)	1,200 (10)	22
Solvent mixture	Tetrahydrofuran Methyl ethyl ketone Methyl isobutyl ketone Toluene Cyclohexanone	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)	See text
Coating head area ventilation:				
Partial enclosure, m^3/s (ft^3/min)	0.15 (310)	0.15 (310)	0.25 (525)	24
Total enclosure, m^3/s (ft^3/min)	0.14 (300)	0.14 (300)	0.24 (500)	
Oven ventilation rate:				
m^3/s, actual	0.28	0.28	2.8	24
standard[c]	0.26	0.26	2.6	
(ft^3/min), actual	(600)	(600)	(6,000)	
standard	(550)	(550)	(5,500)	
Oven temperature, K (°F)	355 (180)	355 (180)	355 (180)	25
Carbon adsorber inlet temperature, K (°F)	311 (100)	311 (100)	311 (100)	25
Incinerator heat exchanger inlet temperature, K (°F)	344 160	344 160	344 160	
Solvent concentration in exhaust: % LEL	25	25	25	25
ppmV	~2,500	~2,500	~2,500	
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)	23 (25)	68 (75)	635 (700)	23

[a] μm = micrometer.

[b] mil = 0.001 inch.

[c] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.

TABLE 6-5. MODEL COATING OPERATION PARAMETERS FOR CONDENSERS RECOVERING CYCLOHEXANONE

Line designation:	Research[a]	Small[a]	Typical	Ref.
1. Line information				
Web width, m (in.)			0.66 (26)	22
Line speed, m/s (ft/min)			2.5 (500)	22
Operating h/yr			6,000	
2. Process information				
Coating thickness, wet, μm[b] (mil)[c]			25 (1)	22
Coating formulation:				
% VOC, weight			63	22
% VOC, volume			80	22
Density, kg/m³ (lb/gal)			1,200 (10)	22
Solvent mixture			Cyclohexanone (100%)	See text
Coating head area ventilation:				
Partial enclosure, m³/s (ft³/min)			0.25 (525)	24
Total enclosure, m³/s (ft³/min)			0.24 (500)	
Oven ventilation rate:				
System 1				
m³/s, actual			1.75	24
standard[d]			1.6	
(ft³/min), actual			(3,700)	
standard[d]			(3,400)	
System 2[e]				
m³/s, actual			1.65	24
standard[d]			1.42	
(ft³/min), actual			3,500	
standard			(3,000)	
Oven temperature, K (°F)			180 (355)	25
Control device inlet temperature, K (°F)			160 (344)	25
Solvent concentration in exhaust:				
System 1: % LEL			40	26
ppmV			~4,000	
System 2: % vol. solvent nitrogen atmosphere			10	27
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)			635 (700)	23

[a] Condensers cannot be sized for research and small lines.
[b] μm = micrometer.
[c] mil = 0.001 inches.
[d] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.
[e] Volume sent to condensation module; system cannot be designed for the research and small coating operations.

TABLE 6-6. MODEL COATING OPERATION PARAMETERS FOR CONDENSERS RECOVERING SOLVENT MIXTURES

Line designation:	Research[a]	Small[a]	Typical	Ref.
1. Line information				
Web width, m (in.)			0.66 (26)	22
Line speed, m/s (ft/min)			2.5 (500)	22
Operating h/yr			6,000	
2. Process information				
Coating thickness, wet, µm[b] (mil)[c]			25 (1)	22
Coating formulation:				
% VOC, weight			63	22
% VOC, volume			80	22
Density, kg/m^3 (lb/gal)			1,200 (10)	22
Solvent mixture			Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)	See text
Coating head area ventilation				
Partial enclosure, m^3/s (ft^3/min)			0.25 (525)	24
Total enclosure, m^3/s (ft^3/min)			0.24 (500)	
Oven ventilation rate:				
System 1				
m^3/s, actual			1.75	24
standard[d]			1.6	
(ft^3/min), actual			(3,700)	
standard			(3,400)	
System 2[e]				
m^3/s, actual			1.65	24
standard[d]			1.42	
(ft^3/min), actual			3,500	
standard			(3,000)	
Oven temperature, K (°F)			180 (355)	25
Control device inlet temperature, K (°F)			160 (344)	25
Solvent concentration in exhaust:				
System 1: % LEL			40	26
ppmV			~4,000	
System 2: % vol. solvent nitrogen atmosphere			10	27
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)			635 (700)	23

[a] Condensers cannot be sized for research and small lines.

[b] µm = micrometer.

[c] mil = 0.001 inches.

[d] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.

[e] Volume sent to condensation module; systems cannot be designed for the research and small coating operations.

TABLE 6-7. CONTROL OPTIONS FOR SOLVENT STORAGE TANKS*

Control option	Control device	Overall VOC control,[a] %
1	None	0
2	Conservation vents	35[b]
3A	Separate fixed-bed carbon adsorber on storage tank emissions alone	95
3B	Common fixed-bed carbon adsorber on combined storage tank and coating operation emissions	95

*These control options have been revised. See Table F-2 in Appendix F.

[a] Of emissions from solvent storage tanks only, not the entire line.

[b] Average control efficiency based on model line solvents and tank sizes.

TABLE 6-8. CONTROL OPTIONS FOR COATING MIX ROOM

Control option	Control device	Overall VOC control,[b] %
	Mixers Mills[a] Tanks	
1	None	0
2	Vapor tight covers and conservation vents[c]	40
3A	Vapor tight covers ducted to a separate fixed-bed carbon adsorber on mix room emissions alone	95
3B	Vapor tight covers ducted to a common fixed-bed carbon adsorber on combined mix room and coating operation emissions	95

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[a] For mills other than sealed and pressurized sand mills.

[b] Of emissions from mix room only, not from entire line.

[c] The equipment has no areas that are directly open to the air. This may be achieved by use of packing glands, tight covers, or lids on the equipment.

TABLE 6-9. CONTROL OPTIONS FOR COATING OPERATIONS

Control	Emission capture system			Overall VOC
option	Coating area	Drying oven[a]	Control device	control,[b] %
1A	None	No	None	0
1B	None	Yes	Carbon adsorber or condenser	83
2A	Partial enclosure	Yes	Carbon adsorber	87
2B	Partial enclosure	Yes	Condenser[c]	87
3A	Total enclosure	Yes	Carbon adsorber	93
3B	Total enclosure	Yes	Condenser[c,d]	93
4	Total enclosure	Yes	Incinerator	95

[a] Assumed to be well designed oven with no losses to room; always vented to the control device in controlled plants.

[b] Of emissions from coating operation only, not the entire line.

[c] Condenser 1 used to control effluent from enclosure and from oven.

[d] Condenser 2 used to control effluent from nitrogen-purged total enclosure and effluent from drying oven with nitrogen atmosphere.

TABLE 6-10. REGULATORY ALTERNATIVES AND CONTROL DEVICE CONFIGURATIONS FOR IMPACT ANALYSIS

Reg. Alt.	Emission capture			Control device			Overall VOC control, %
	Mix room	Coating operation		Storage tanks	Mix room	Coating operation	
		Flashoff	Oven[a]				
I	None	None	None	None	None	None	0
II	Covered/vented	None	None	Conservation vent	Conservation vent	None	4
III	Covered/vented	None	None	Conservation vent	Carbon adsorber	None	9
IV	None	None	Yes	None	None	Carbon adsorber or condenser	75
V	None	Partial encl.	Yes	Conservation vent	None	Carbon adsorber or condenser[b]	78
VI	Covered/vented	None	Yes	Conservation vent	Conservation vent	Carbon adsorber or condenser	79
VII	Covered/vented	Partial encl.	Yes	Conservation vent	Conservation vent	Carbon adsorber or condenser[b]	82
VIII	None	Total encl.	Yes	Conservation vent	None	Carbon adsorber or condenser[b,c]	83
IX	Covered/vented	None	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser	84
X	None	Total encl.	Yes	Conservation vent	None	Incinerator	85
XIA	Covered/vented	Total encl.	Yes	Conservation vent	Conservation vent	Carbon adsorber or condenser[b,c]	87
XIB	Covered/vented	Partial encl.	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser[b]	87
XII	Covered/vented	Total encl.	Yes	Conservation vent	Conservation vent	Incinerator	89
XIII	Covered/vented	Total encl.	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser[b,c]	93
XIV	Covered/vented	Total encl.	Yes	Conservation vent	Carbon adsorber	Incinerator	94

[a] Assumed to be well designed oven with no losses to room; always vented to the control device in controlled lines.

[b] Condenser 1 used to control effluent from enclosure and from oven.

[c] Condenser 2 used to control effluent from nitrogen-purged total enclosure and effluent from drying oven with nitrogen atmosphere.

[d] Mix room emissions will be controlled by (a) the fixed-bed carbon adsorber used to control VOC emissions from the coating operation or by (b) a separate fixed-bed carbon adsorber for the mix room emissions.

TABLE 6-11. BASIS OF OVERALL CONTROL LEVEL FOR REGULATORY ALTERNATIVES

Reg. Alt.	Percent of emissions captured[a] Mix room[b]	Percent of emissions captured[a] Coating operations[c]	Control device efficiency, percent	Percent overall VOC control
I	0	0	0	0
II	100	0	60	4
III	100	0	95	9
IV	0	90	95	75[d]
V	0	95	95	78[d]
VIII	0	100	95	83[d]
X	0	100	98	85[d]

[a] Percent of total emissions within each area that is captured and sent to a control device.

[b] About 10 percent of the combined emissions from the mix room and coating operation are from the mix room equipment.

[c] About 90 percent of the combined emissions from the mix room and coating operation are from the coating operation (application/flashoff area and drying oven).

[d] Represents the calculated value that has been rounded and reduced by 2 to 3 percent to account for uncertainties in capture efficiency of emissions from the application/flashoff area and drying oven.

6.5 REFERENCES FOR CHAPTER 6

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7. ENVIRONMENTAL AND ENERGY IMPACTS

An analysis of the environmental and energy impacts of the regulatory alternatives for the magnetic tape coating model lines (combined solvent storage tanks, mix preparation equipment, and coating operation) is presented in this chapter. (Appendix E presents the environmental and energy impacts for each of the three emission sources.) The incremental increase or decrease in air pollution, water pollution, solid waste generation, and energy consumption for the regulatory alternatives compared to baseline are discussed. These impacts are examined for individual lines and nationwide. Baseline I (0 percent control) represents uncontrolled plants and is the level of control that is presently required of plants that emit less than 227 Mg (250 tons) of volatile organic compound (VOC) per year and are located in ozone attainment areas. Baseline IV (75 percent control) represents the level of control that is required of all plants in nonattainment areas for ozone and of plants that emit 227 Mg (250 tons) or more and are located in ozone attainment areas. Table 7-1 presents the regulatory alternatives and control device configurations used in the impact analyses.

7.1 AIR POLLUTION IMPACTS

Volatile organic compounds are emitted from several points in the production of magnetic tape. The drying oven used to evaporate the solvent and cure the resin is the largest single source of VOC emissions. Fugitive VOC emissions are emitted from around the coating application/flashoff area. Volatile organic compound emissions also occur in the mix room during solvent handling and coating formulation activities and from solvent storage tanks. In an uncontrolled line, the entire amount of solvent used is vented to the atmosphere. The VOC emissions can be controlled by use of add-on control equipment such as carbon adsorbers, incinerators, and condensers. Carbon adsorber and condenser control systems recover solvent for reuse in coating mix formulations.

7.1.1 Primary Air Pollution Impacts

The annual VOC emission levels associated with application of each regulatory alternative on each model line are presented in Table 7-2. The annual emissions were calculated using the model storage tank, mix room, and coating operation parameters given in Chapter 6. The annual uncontrolled VOC emissions (Regulatory Alternative I), are 25 Mg (28 tons), 75 Mg (83 tons), and 706 Mg (778 tons) for the research, small, and typical model lines, respectively. The annual VOC emissions for Regulatory

Alternatives II through XIV range from 2 to 24 Mg (2 to 27 tons) for the research model line, 5 to 73 Mg (5 to 80 tons) for the small model line, and 42 to 678 Mg (47 to 747 tons) for the typical model line. The annual VOC emission incremental reduction below uncontrolled (Regulatory Alternative I) and below controlled (Regulatory Alternative IV) baselines are given in Table 7-3.

Table 7-4 presents the estimated national VOC emissions from new magnetic tape coating lines from 1985 to 1990. These emission estimates are calculated based on predicted industry growth for the first 5 years that the standards will be in effect. In 1990, a projected 21 new magnetic tape coating lines would have the potential to emit approximately 8,170 Mg (9,000 tons) per year of uncontrolled VOC. These new lines will have solvent usages equivalent to 1 research line, 5 small lines, and 11 typical sized lines. (Refer to Chapter 9 for a discussion of the growth projections.) The controlled baseline Regulatory Alternative IV would lower VOC emissions to 2,040 Mg (2,250 tons) per year. The most stringent level of the proposed NSPS, Alternative XIV, would reduce VOC emissions in 1990 to 480 Mg (530 tons) per year.

The primary impact of a VOC emission reduction in this industry is a potential decline in ambient VOC levels and, thus, a reduction in ozone and photochemical smog formation. For plants in rural areas or areas of low ambient nitrogen oxide and ozone concentrations, the primary environmental impact is the prevention of transport of VOC's in the atmosphere to locations where ozone and photochemical smog are problems.

7.1.2 Secondary Air Pollution Impacts

Secondary emissions of air pollutants result from generation of the energy required to operate the control devices. Electrical energy is needed primarily to operate the motors and fans used to capture and convey gases to different sections of the control system. Generation of the electric power required to operate carbon adsorbers, incinerators, and condensers will result in particulate matter (PM), sulfur oxide (SO_x), and nitrogen oxide (NO_x) emissions. The combustion of natural gas in incinerators will result in PM, NO_x, and carbon monoxide (CO) emissions. The combustion of fuel oil in the boiler used to produce steam for the fixed-bed carbon adsorption system will also result in PM, SO_x, and NO_x emissions.

Secondary emissions were calculated assuming that electric power to the control device was supplied by a coal-fired power plant. It was assumed that the thermal efficiency of the electric generator was 33 percent. For all types of power plants and all ages of plants, the estimated emissions per Btu of heat input in 1990 are approximately equal to the current new source performance standards (NSPS) for coal-fired power plants.[1] Therefore, the secondary emissions were calculated using the NSPS values.[2] The applicable standards limit PM emissions to 15 kg/TJ*

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*TJ = terajoules = 10^{12} joules.

(0.03 lb/10^6 Btu) of heat input, SO_x emissions to 520 kg/TJ (1.20 lb/10^6 Btu) of heat input, and NO_x emissions to 260 kg/TJ (0.60 lb/10^6 Btu) of heat input.[3] The annual secondary pollutant emission levels from electrical energy generation associated with application of each regulatory alternative on each model line are presented in Appendix E. (See Section 7.4 for electrical energy requirements for each alternative.) Annual emissions of PM range from 0.01 to 0.5 kg (0.03 to 1 lb) for research lines, 0.06 to 2 kg (0.14 to 4 lb) for small lines, and 0.08 to 160 kg (0.18 to 310 lb) for typical lines. The annual SO_x emissions range from 0.5 to 40 kg (1 to 90 lb) for research lines, 3 to 80 kg (6 to 180 lb) for small lines, and 3 to 5,470 kg (7 to 11,960 lb) for typical lines. The annual NO_x emissions range from 0.3 to 20 kg (0.6 to 40 lb) for research lines, 1 to 40 kg (3 to 80 lb) for small lines, and 2 to 2,740 kg (4 to 5,980 lb) for typical lines.

The combustion of natural gas as supplemental fuel in incinerator control devices results in secondary air pollutants. Assuming the incinerator generates pollutants at a rate comparable to that of an industrial process boiler, the secondary emissions were calculated using emission rates of 7 kg/TJ (0.016 lb/10^6 Btu) of heat input for PM, 12 kg/TJ (0.028 lb/10^6 Btu) for CO, and 123 kg/TJ (0.285 lb/10^6 Btu) for NO_x.[4] The annual secondary emissions for Regulatory Alternatives X, XII, and XIV (i.e., the only alternatives that require the combustion of natural gas) for each model line are in Appendix E. (See Section 7.4 for natural gas requirements for these alternatives.)

The major secondary air pollution impacts for fixed-bed carbon adsorption systems are the emissions from the boiler used to produce steam. The steam is used to strip the carbon bed of adsorbed VOC at a ratio of 4 kilograms of steam per kilogram recovered solvent (4 lb steam/lb solvent). Assuming that the model plants use fuel oil containing 1.5 percent sulfur by weight and that the thermal efficiency of the boiler is 80 percent, estimates can be made of the levels of secondary emissions. For PM, the emission rate is 50 kg/TJ (0.12 lb/ 10^6 Btu) of heat input; for SO_x, it is 690 kg/TJ (1.6 lb/10^6 Btu); and for NO_x, it is 170 kg/TJ (0.4 lb/10^6 Btu).[5] The secondary emissions for those regulatory alternatives that require the generation of steam are presented in Appendix E. (See Section 7.4 for steam requirements for each alternative.) Annual emissions of PM range from 2 to 20 kg (4 to 30 lb) for research lines, 5 to 40 kg (10 to 100 lb) for small lines, and 40 to 710 kg (100 to 1,610 lb) for typical lines. The annual SO_x emissions range from 20 to 220 kg (50 to 450 lb) for research lines, 60 to 610 kg (130 to 1,330 lb) for small lines, and 580 to 9,620 kg (1,280 to 21,160 lb) for typical lines. The annual NO_x emissions range from 5 to 50 kg (10 to 110 lb) for research lines, 20 to 150 kg (30 to 340 lb) for small lines, and 150 to 2,400 kg (330 to 5,360 lb) for typical lines.

The magnitude of the secondary pollutants generated by the operation of the control system is much smaller than the magnitude of solvent emissions being recovered. For the worst case, a typical line with a condenser (air atmosphere) controlling emissions from the coating operation and a fixed-bed carbon adsorber controlling emissions from the mix room, 18 Mg (20 tons) of secondary pollutants are emitted annually, while VOC emissions are reduced from 706 to 57 Mg (778 to 62 tons) annually.

7.2 WATER POLLUTION IMPACTS

There are no wastewater effluents from an uncontrolled magnetic tape coating line. Wastewater problems arise, however, from the use of fixed-bed carbon adsorbers. Fluidized-bed carbon adsorbers, incinerators, and condensers have no wastewater discharges.

In a fixed-bed carbon adsorption system, water is used to produce steam, which is then used to strip adsorbed solvent from the carbon beds. Upon completion of the stripping operation, the solvent-steam vapors are condensed and fed to a decanter where the water insoluble organic layer separates from the water and water soluble organic layer. The wastewater discharged after the solvent has been decanted poses a potential adverse environmental impact resulting from possible organic contamination of the water. Trace concentrations of solvent may become fixed in the water during the operation of the condensation stage, even though the solvent is considered immiscible in water.

7.2.1 Line Wastewater Emissions

For the typical line, the water phase from the decanter was assumed to be processed in a stripper column to remove the dissolved organics. Based on typical stripper column design, the aqueous bottoms from the stripper column contains 100 ppm VOC.[6-8] Because this is the level most plants are required to meet, the cost of a more efficient stripper column was not included. If State or local regulations require further reduced levels of waterborne VOC's, they can be cost effectively achieved.[9] The potential impacts of the organics are further lessened because of the availability of an ample number of water pollution control technologies. These treatment technologies include recycling the condensate into the steam-generating system, which could allow a reduction of solvent discharge.[10] The effects on boiler life are undetermined. Other control options are aqueous-phase carbon adsorption, activated sludge treatment, and oxidation of the organics.[10,11]

Table 7-5 presents the annual wastewater discharges associated with each model line and regulatory alternative requiring fixed-bed carbon adsorber control. Wastewater containing solvent from research and small lines is disposed of as hazardous waste. As shown, annual wastewater discharges for a typical line range from 1,590,000 to 1,980,000 liters (420,000 to 520,000 gal). The annual waterborne VOC emissions associated with each regulatory alternative are presented in Table 7-6.

7.2.2. National Wastewater Impacts

The national wastewater discharges in the fifth year after implementation of the standard, 1990, are presented in Table 7-7. In calculating these totals, it was assumed that every line using a solvent-borne coating technology employed fixed-bed carbon adsorption controls. Because of this assumption, the figures given represent a worst-case situation for wastewater discharges.

In 1990, magnetic tape coating lines controlled to the Alternative IV level would discharge approximately 17,490,000 liters (4,620,000 gal) of wastewater per year. The largest increase in wastewater occurs under Alternative XIB which would result in approximately 20,570,000 liters (5,390,000 gal) of wastewater discharges annually.

The amount of VOC being emitted in these national wastewater discharges would be relatively small. In 1990, under Regulatory Alternative IV, the wastewater streams of fixed-bed carbon adsorber control systems would contain about 1,740 kg (3,830 lb) of VOC. Increasing the required control level to Alternative XIII would increase the quantity of VOC discharged in wastewater streams to 2,200 kg (4,730 lb) per year. These impacts are based on the assumptions that all new plants would use a fixed-bed carbon adsorber and all wastewater is discharged with no process recycle and reuse or treatment. Table 7-8 illustrates the impacts of VOC in the control system wastewater discharges.

7.3 SOLID WASTE IMPACTS

7.3.1 Line Impacts

The only solid waste impacts from the add-on control systems comes from carbon adsorption units. The activated carbon in these units gradually degrades during normal operation. The efficiency of the carbon eventually drops to a level such that replacement is necessary, thereby creating a solid waste load. The average carbon life was estimated to be 5 years for fixed-bed carbon adsorbers and 1 year for fluidized-bed carbon adsorbers.[11-13] The amount of waste generated annually for various size lines for each of the regulatory alternatives is presented in Table 7-9. Annual solid waste disposal impacts range from 9 to 85 kg (20 to 188 lb) for a research line, 9 to 85 kg (20 to 188 lb) for a small line, and 58 to 1,880 kg (117 to 4,120 lb) for a typical line. Three alternatives are available for handling the waste carbon material: (1) landfilling the carbon, (2) reactivating the carbon and reusing it in the adsorber, and (3) using the carbon as fuel. Landfilling is simple and efficient because the technology for the operation is considered common practice. No environmental problems would occur if the landfill site has been properly constructed. If the site is not secured by a lining of some type (either natural or artificial), possible soil leaching could occur. The leachate may contain traces of organics which have been left on the carbon as residues. Transmission of this leachate into ground and surface waters would represent a potential environmental impact.

The second, and most common, alternative for handling the waste carbon material does not create any significant amount of solid waste. Most of the carbon is reactivated and reused in the carbon adsorber. Disposal of waste carbon represents only 5 to 10 percent of the carbon used. Disposal of this waste by landfilling poses minimal environmental problems provided the landfill site is properly constructed.

The third method involves selling the waste carbon as a fuel. The physical and chemical structure of the carbon in combination with the hydrocarbon residues make the waste a fuel product similar to other solid fuels such as coal. Potential users of this fuel include industrial and small utility boilers. Because activated carbon generally contains very little sulfur, furnace SO_2 emissions resulting from combustion would be negligible. Particulate and NO_x emissions from the burning of activated carbon would be comparable to those of coal-fired operations. However, the use of this disposal method would be limited because of the small quantities of carbon generated by lines in this industry.

7.3.2 National Solid Waste Impacts

The estimated national solid waste impacts attributable to each regulatory alternative are presented in Table 7-10. It was assumed that all new magnetic tape coating lines used fixed-bed carbon adsorption control systems. None of the regulatory alternatives will have a significant impact on baseline solid waste generation. In 1990, lines controlled to the level of Alternative IV would generate approximately 8,170 kg (17,970 lb) per year of waste carbon. The same lines controlled to the level of Alternative XIII would generate about 9,730 kg (21,370 lb) of waste carbon.

7.4 ENERGY IMPACTS

The air emission control equipment for the magnetic tape coating industry utilizes two forms of energy: electrical energy and fossil fuel energy. Electrical energy is used in the carbon adsorber, incinerator, and condensation control systems. The electrical energy is required to operate fans, cooling tower pumps and fans, boiler support systems, and all control system instrumentation. Fuel oil is used in steam generation for fixed-bed carbon adsorption units and natural gas is used for supplemental fuel in incineration units. Electrical energy and steam are also required for the distillation systems used to separate and purify recovered solvents from typical sized lines.

7.4.1 Electricity and Fossil Fuel Impacts

The annual electricity consumption calculated for each model line and regulatory alternative is presented in Table 7-11. Table 7-12 shows the annual natural gas demand for incinerators associated with Regulatory Alternatives X, XII, and XIV. Incinerators may use primary or secondary heat recovery to reduce energy consumption. A heat recovery factor of 35 percent was used in the energy analysis. Table 7-13 shows the annual steam demand for each model plant and regulatory alternative. The total annual energy demand and incremental increase or decrease over baseline for each regulatory alternative is presented in Table 7-14.

Comparison of the total energy demand of each regulatory alternative shows that energy consumption does not increase significantly with increased VOC control, except for regulatory alternatives requiring incinerators.

7.4.2 National Energy Impacts

The 1990 national energy impacts from the installation of emission control technologies in the magnetic tape coating industry are presented in Table 7-15. If all magnetic tape coating lines were controlled by carbon adsorption to the Alternative XIII level, an incremental energy demand of approximately 15,280 GJ (14,570 x10^6 Btu) is projected compared to baseline (Regulatory Alternative IV). The worst-case energy situation would occur if incinerators were used to control all new magnetic tape coating operations and carbon adsorbers were used to control mix equipment. This would require 182,590 GJ (172,790 x10^6 Btu) of energy compared to baseline (Regulatory Alternative IV), which would require 119,400 GJ (113,170 x10^6 Btu) for carbon adsorber control.

7.5 OTHER ENVIRONMENTAL IMPACTS

The impact of increased noise levels is not a significant problem with the emission control systems used in the magnetic tape coating industry. No noticeable increases in noise levels occur as a result of increasingly stricter regulatory alternatives. Fans and motors, present in the majority of the systems, are responsible for the bulk of the noise in the control operations.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

As discussed in Section 7.4, the regulatory alternatives will result in an increase in the irreversible and irretrievable commitment of energy resources. However, this increased energy demand for pollution control by carbon adsorption systems, condensers, and incinerators is insignificant compared to the total line energy demand. Model line energy demands are presented in Table 6-1.

7.6.2 Environmental Impact of Delayed Standard

Because the water pollution and energy impacts are small, there is no significant benefit to be obtained from delaying the proposed standards. Furthermore, there does not appear to be any emerging emission control technology that achieves greater emissions reduction or that achieves an emission reduction equal to that of the regulatory alternatives at a lower cost than those represented by the control devices considered here. Consequently, there are no benefits or advantages to delaying the proposed standards.

TABLE 7-1. REGULATORY ALTERNATIVES AND CONTROL DEVICE CONFIGURATIONS FOR IMPACT ANALYSIS

Reg. Alt.	Emission capture			Control device			Overall VOC control, %
		Coating operation					
	Mix room	Flashoff	Oven[a]	Storage tanks*	Mix room	Coating operation	
I	None	None	None	None	None	None	0
II	Covered/vented	None	None	Conservation vent	Covers	None	4
III	Covered/vented	None	None	Conservation vent	Carbon adsorber	None	9
IV	None	None	Yes	None	None	Carbon adsorber or condenser	75
V	None	Partial encl.	Yes	Conservation vent	None	Carbon adsorber or condenser[b]	78
VI	Covered/vented	None	Yes	Conservation vent	Covers	Carbon adsorber or condenser	79
VII	Covered/vented	Partial encl.	Yes	Conservation vent	Covers	Carbon adsorber or condenser[b]	82
VIII	None	Total encl.	Yes	Conservation vent	None	Carbon adsorber or condenser[b,c]	83
IX	Covered/vented	None	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser	84
X	None	Total encl.	Yes	Conservation vent	None	Incinerator	85
XIA	Covered/vented	Total encl.	Yes	Conservation vent	Covers	Carbon adsorber or condenser[b,c]	87
XIB	Covered/vented	Partial encl.	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser[b]	87
XII	Covered/vented	Total encl.	Yes	Conservation vent	Covers	Incinerator	89
XIII	Covered/vented	Total encl.	Yes	Conservation vent	Carbon adsorber[d]	Carbon adsorber or condenser[b,c]	93
XIV	Covered/vented	Total encl.	Yes	Conservation vent	Carbon adsorber	Incinerator	94

[a] Assumed to be well designed oven with no losses to room; always vented to the control device in controlled facilities.

[b] Condenser 1 used to control effluent from enclosure and from oven.

[c] Condenser 2 used to control effluent from nitrogen purged total enclosure and effluent from drying oven with nitrogen atmosphere.

[d] Mix room emissions will be controlled by (a) the fixed-bed carbon adsorber used to control VOC emissions from the coating operation or by (b) a separate fixed-bed carbon adsorber for the mix room emissions.

*The control options for solvent storage tanks have been revised. See Table F-1 in Appendix F for the revisions.

TABLE 7-2. ANNUAL VOC EMISSION LEVELS FOR MODEL MAGNETIC TAPE COATING LINES[a]*

	Emission level[b]					
	Research		Small		Typical	
Reg. Alt.	Mg	Tons	Mg	Tons	Mg	Tons
I	25	28	75	83	706	778
II	24	27	72	80	678	747
III	23	25	68	76	642	708
IV	6	7	19	21	176	194
V	5	6	16	18	155	171
VI	5	6	16	17	148	163
VII	4	5	14	15	127	140
VIII	4	5	13	14	120	132
IX	4	5	12	13	113	124
X	4	5	11	12	106	117
XIA	3	4	10	11	92	101
XIB	3	4	10	11	92	101
XII	3	3	8	9	78	86
XIII	2	2	5	6	49	54
XIV	2	2	4	5	42	47

[a] Emissions from solvent storage, preparation of coating mix, and coating and drying of magnetic tape.

[b] Metric and English units may not convert exactly due to independent rounding.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-3 for these revisions. The changes are very small and would change the values in this table only slightly, if it all.

TABLE 7-3. ANNUAL VOC EMISSION REDUCTION BELOW BASELINE FOR MODEL MAGNETIC TAPE COATING LINES[a,b]*

Reg. Alt.	Research				Small				Typical			
	I[c]		IV[d]		I[c]		IV[d]		I[c]		IV[d]	
	Mg	Tons	Mg	Tons	Mg	Tons	Mg	Tons	Mg	Tons	Mg	Tons
II[e]	1	1	--	--	3	3	--	--	28	31	--	--
III[e]	2	3	--	--	7	7	--	--	64	70	--	--
IV	19	21	0	0	56	62	0	0	530	584	0	0
V	20	22	1	1	59	65	3	3	551	607	21	23
VI	20	22	1	1	59	66	3	4	558	615	28	31
VII	21	23	2	1	61	68	5	6	579	638	49	54
VIII	21	23	2	2	62	69	6	7	586	646	56	62
IX	21	23	2	2	63	70	7	8	593	654	63	70
X	21	23	2	2	64	71	8	9	600	661	70	77
XIA	22	24	3	2	65	72	9	10	614	677	84	93
XIB	22	24	3	3	65	72	9	10	614	677	84	93
XII	22	25	3	3	67	74	11	12	628	692	98	108
XIII	23	26	4	5	70	77	14	15	657	724	127	140
XIV	23	26	4	5	71	78	15	16	664	731	134	147

[a] Emissions from solvent storage, preparation of coating mix, and coating and drying of magnetic tape.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Uncontrolled baseline.

[d] Controlled baseline (75 percent control).

[e] Baseline for these alternatives is uncontrolled (Regulatory Alternative I).

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-3 for these revisions. The changes are very small and would change the values in this table only slightly, if at all.

TABLE 7-4. ESTIMATED 1990 NATIONAL VOC EMISSIONS FROM MAGNETIC TAPE COATING LINES[a]*

Reg. Alt.	Research[b]		Small[b]		Typical[b]		Total[b]	
	Mg	Tons	Mg	Tons	Mg	Tons	Mg	Tons
I	25	28	375	415	7,766	8,558	8,170	9,000
II	24	27	360	400	7,458	8,217	7,840	8,640
III	23	25	340	380	7,062	7,788	7,420	8,190
IV	6	7	95	105	1,936	2,134	2,040	2,250
V	5	6	80	90	1,705	1,881	1,790	1,980
VI	5	6	80	85	1,628	1,793	1,710	1,880
VII	4	5	70	75	1,397	1,540	1,470	1,620
VIII	4	5	65	70	1,320	1,452	1,390	1,530
IX	4	5	60	65	1,243	1,364	1,310	1,430
X	4	5	55	60	1,166	1,287	1,220	1,350
XIA	3	4	50	55	1,012	1,111	1,060	1,170
XIB	3	4	50	55	1,012	1,111	1,060	1,170
XII	3	3	40	45	858	946	900	990
XIII	2	2	25	30	539	594	570	630
XIV	2	2	20	25	462	517	480	540

[a] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[b] Metric and English units may not convert exactly due to independent rounding.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 through F-4 for the revisions. The changes are very small and would change the values in this table only slightly, if at all.

TABLE 7-5. ANNUAL WASTEWATER DISCHARGES FOR THE CONTROL EQUIPMENT FOR MODEL MAGNETIC TAPE COATING LINES[a],[14]

Reg. Alt.[b]	Typical[c]	
	10^3 ℓ	10^3 gal
III[d]	0	0
IV	1,590	420
V	1,670	440
VI	1,590	420
VII	1,670	440
VIII	1,780	470
IX	1,790	470
IX[d]	0	0
XIA	1,780	470
XIB	1,870	490
XIB[d]	0	0
XIII	1,980	520
XIII[d]	0	0
XIV[d]	0	0

[a] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[b] Regulatory alternatives that include fixed-bed carbon adsorbers.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Wastewater containing solvent from control of mix room only is disposed as hazardous waste.

TABLE 7-6. ANNUAL WATERBORNE VOC EMISSIONS FROM THE CONTROL EQUIPMENT FOR MODEL MAGNETIC TAPE COATING LINES[a,b,14]

Reg. Alt.[c]	Typical[d]	
	kg	lb
III[e]	0	0
IV	158	348
V	170	370
VI	158	348
VII	170	370
VIII	177	390
IX	190	410
IX[e]	0	0
XIA	177	390
XIB	190	410
XIB[e]	0	0
XIII	200	430
XIII[e]	0	0
XIV[e]	0	0

[a] Wastewater from stripper column of distillation system contains 100 ppm VOC.

[b] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[c] Regulatory alternatives that include fixed-bed carbon adsorbers.

[d] Metric and English units may not convert exactly due to independent rounding.

[e] Wastewater containing solvent from control of mix room is disposed as hazardous waste.

TABLE 7-7. ESTIMATED 1990 NATIONAL WASTEWATER DISCHARGES FROM MAGNETIC TAPE COATING LINES[a]

Reg. Alt.[b]	10^3 liters[c]	10^3 gal[c]
III[d]	0	0
IV	17,490	4,620
V	18,370	4,840
VI	17,490	4,620
VII	18,370	4,840
VIII	19,580	5,170
IX	17,690	4,620
IX[d]	0	0
XIA	19,580	5,170
XIB	20,570	5,390
XIB[d]	0	0
XIII	21,780	5,720
XIII[d]	0	0
XIV[d]	0	0

[a] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[b] Regulatory alternatives that include fixed-bed carbon adsorbers.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Wastewater containing solvent from control of mix room only is disposed as hazardous waste.

TABLE 7-8. ESTIMATED 1990 NATIONAL WATERBORNE VOC EMISSIONS FROM MAGNETIC TAPE COATING LINES[a,b]

Reg. Alt.[c]	kg[d]	lb[d]
III[e]	0	0
IV	1,740	3,830
V	1,870	4,070
VI	1,740	3,830
VII	1,870	4,070
VIII	1,950	4,290
IX	2,090	4,510
IX[e]	0	0
XIA	1,950	4,290
XIB	2,090	4,510
XIB[e]	0	0
XIII	2,200	4,730
XIII[e]	0	0
XIV[e]	0	0

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[a] Wastewater from stripper column of distillation system contains 100 ppm VOC.

[b] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[c] Regulatory alternatives that include fixed-bed carbon adsorbers.

[d] Metric and English units may not convert exactly due to independent rounding.

[e] Wastewater containing solvent from control of mix room is disposed as hazardous waste.

TABLE 7-9. SOLID WASTE IMPACTS OF THE REGULATORY ALTERNATIVES ON THE MODEL LINES[a]

Reg. Alt.	Research		Small		Typical	
	kg	lb	kg	lb	kg	lb
III	9	20	9	20	58	117
IV[b]	71	156	71	156	704	1,548
IV[c]	0	0	0	0	1,820	4,000
V[b]	73	160	73	160	727	1,600
V[c]	0	0	0	0	1,820	4,000
VI[b]	71	156	71	156	704	1,548
VI[c]	0	0	0	0	1,820	4,000
VII[b]	73	160	73	160	727	1,600
VII[c]	0	0	0	0	1,820	4,000
VIII[b]	76	170	76	170	780	1,700
VIII[c]	0	0	0	0	1,820	4,000
IX[b]	80	176	80	176	762	1,665
IX[c]	0	0	0	0	1,878	4,130
XIA[b]	76	168	76	168	775	1,730
XIA[c]	0	0	0	0	1,820	4,000
XIB[b]	82	180	82	180	788	1,730
XIB[c]	0	0	0	0	1,878	4,130
XIII[b]	85	188	85	188	838	1,840
XIII[c]	0	0	0	0	1,878	4,130
XIV	9	20	9	20	58	117

[a] Carbon wastes from alternatives requiring the operation of carbon adsorbers.

[b] Fixed-bed carbon adsorbers.

[c] Fluidized-bed carbon adsorbers on typical sized lines only.

TABLE 7-10. ESTIMATED 1990 NATIONAL SOLID WASTE IMPACTS[a]

Reg. Alt.	kg	lb
III	690	1,410
IV[b]	8,170	17,960
IV[c]	20,020	44,000
V[b]	8,430	18,560
V[c]	20,020	44,000
VI[b]	8,170	17,960
VI[c]	20,020	44,000
VII[b]	8,430	18,560
VII[c]	20,020	44,000
VIII[b]	9,040	19,660
VIII[c]	20,020	44,000
IX[b]	8,860	19,370
IX[c]	20,660	45,430
XIA[b]	8,980	20,040
XIA[c]	20,020	44,000
XIB[b]	9,160	20,110
XIB[c]	20,660	45,430
XIII[b]	9,730	21,370
XIII[c]	20,660	45,430
XIV	690	1,410

[a] Carbon waste from alternatives requiring carbon adsorbers.

[b] Fixed-bed carbon adsorbers.

[c] Fluidized-bed carbon adsorbers on typical sized lines only.

TABLE7-11. ANNUAL ELECTRICAL ENERGY REQUIREMENTS FOR THE CONTROL EQUIPMENT OF MODEL MAGNETIC TAPE COATING LINES

Reg. Alt.	Coating operation control device[a]	Research[b]		Small[b]		Typical[b]	
		GJ[c]	10^6 Btu	GJ[c]	10^6 Btu	GJ[c]	10^6 Btu
I	None	None	None	None	None	None	None
II	None	--	--	--	--	--	--
III	None[d]	0.37	0.35	1.6	1.5	2.1	2.0
IV, V, VI, VII, VIII, XIA	CA	16	15	48	46	510	480
IV, V, VI, VII, VIII, XIA	RF[e]					3,780	3,590
IV, VI, VIII, XIA	N_2[e]	--	--	--	--	300	290
IX, XIB, XIII	CA	17	16	50	47	510	480
IX, XIB, XIII	RF	--	--	--	--	3,780	3,590
IX, XIII	N_2	--	--	--	--	300	290
X, XII	INC	4	4	14	13	140	130
XIV	INC	5	5	16	15	140	130

[a] CA = Carbon adsorber; RF = Condensation-air refrigeration system; N_2 = Condensation-nitrogen atmosphere system; INC = Incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] GJ = Gigajoules or 10^9 joules; one joule = 0.948×10^{-3} Btu.

[d] Energy requirements are for carbon adsorber used to control mix equipment emissions.

[e] Condensation systems cannot be designed for research or small lines.

TABLE 7-12. ANNUAL NATURAL GAS REQUIREMENTS FOR THE CONTROL EQUIPMENT OF MODEL MAGNETIC TAPE COATING LINES

Reg. Alt.[a]	Research[b]		Small[b]		Typical[b]	
	GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
X, XII, XIV	500	470	1,500	1,420	15,000	14,200

[a] Regulatory alternatives that require the combustion of natural gas.

[b] Metric and English units may not convert exactly due to independent rounding.

TABLE 7-13. ANNUAL STEAM REQUIREMENTS FOR THE CONTROL EQUIPMENT FOR MODEL MAGNETIC TAPE COATING LINES

Reg. Alt.	Research[a]		Small[a]		Typical[a]	
	GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
III	26	25	70	67	690	650
IV[b]	190	180	580	550	10,040	9,520
IV[c]	--	--	--	--	4,640	4,400
V[b]	200	190	600	570	10,290	9,760
V[c]	--	--	--	--	4,640	4,400
VI[b]	190	180	580	550	10,040	9,520
VI[c]	--	--	--	--	4,640	4,400
VII[b]	200	190	600	570	10,290	9,760
VII[c]	--	--	--	--	4,640	4,400
VIII[b]	220	210	650	610	10,680	10,130
VIII[c]	--	--	--	--	4,640	4,400
IX[b]	220	210	650	620	10,730	10,170
IX[c]	--	--	--	--	5,330	5,050
XIA[b]	220	210	650	610	10,680	10,130
XIA[c]	--	--	--	--	4,640	4,400
XIB[b]	230	220	680	640	10,980	10,410
XIB[c]	--	--	--	--	5,330	5,050
XIII[b]	240	230	720	680	11,360	10,780
XIII[c]	--	--	--	--	5,330	5,050
XIV	26	25	70	67	690	650

[a] Metric and English units may not convert exactly due to independent rounding.

[b] For fixed-bed carbon adsorber. Typical plant includes distillation requirements.

[c] For condensation system distillation requirements.

TABLE 7-14. TOTAL ANNUAL ENERGY DEMAND OF CONTROL EQUIPMENT FOR MODEL MAGNETIC TAPE COATING LINES

Reg. Alt.	Coating operation control device[a]		Research[b]		Small[b]		Typical[b]	
			GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
I[c]	None	Total energy	0	0	0	0	0	0
		Incremental	--	--	--	--	--	--
II	None	Total energy	0	0	0	0	0	0
		Incremental	0	0	0	0	0	0
III[d]	None	Total energy	26	25	72	68	689	654
		Incremental	26	25	72	68	689	654
IV[e]	CA	Total energy	209	198	626	594	10,540	10,000
		Incremental	--	--	--	--	--	--
IV[f]	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	--	--	--	--	--	--
IV[g]	N_2	Total energy	--	--	--	--	4,940	4,690
		Incremental	--	--	--	--	--	--
V	CA	Total energy	217	206	653	620	10,800	10,240
		Incremental	8	8	27	23	260	240
V	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	--	--	--	--	0	0
VI	CA	Total energy	209	198	626	494	10,540	10,000
		Incremental	0	0	0	0	0	0
VI	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	--	--	--	--	0	0
VI	N_2	Total energy	--	--	--	--	4,940	4,690
		Incremental	--	--	--	--	0	0
VII	CA	Total energy	217	206	653	620	10,800	10,240
		Incremental	8	8	27	23	260	240
VII	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	--	--	--	--	0	0
VIII	CA	Total energy	232	220	695	660	11,180	10,650
		Incremental	23	22	69	66	640	650
VIII	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	0	0	0	0	0	0
VIII	N_2	Total energy	--	--	--	--	4,940	4,690
		Incremental	--	--	--	--	0	0
IX	CA	Total energy	235	223	698	663	11,234	10,653
		Incremental	26	25	72	69	694	653
IX	RF	Total energy	--	--	--	--	9,109	8,644
		Incremental	--	--	--	--	689	654
IX	N_2	Total energy	--	--	--	--	5,630	5,340
		Incremental	--	--	--	--	690	650
X	INC	Total energy	505	474	1,514	1,433	15,140	14,333
		Incremental	296	276	888	839	4,600	4,333
XIA	CA	Total energy	232	220	695	660	11,184	10,608
		Incremental	23	22	69	66	644	608
XIA	RF	Total energy	--	--	--	--	8,420	7,990
		Incremental	--	--	--	--	0	0
XIA	N_2	Total energy	--	--	--	--	4,941	4,690
		Incremental	--	--	--	--	0	0

(continued)

TABLE 7-14. (continued)

Reg. Alt.	Coating operation control device[a]		Research[b]		Small[b]		Typical[b]	
			GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
XIB	CA	Total energy	243	231	725	688	11,484	10,893
		Incremental	34	33	99	94	944	893
XIB	RF	Total energy	--	--	--	--	9,109	8,644
		Incremental	--	--	--	--	689	654
XII	INC	Total energy	505	474	1,514	1,433	15,140	14,333
		Incremental	296	276	888	839	4,600	4,333
XIII	CA	Total energy	258	245	765	728	11,873	11,262
		Incremental	49	47	139	134	1,333	1,262
XIII	RF	Total energy	--	--	--	--	9,109	8,644
		Incremental	--	--	--	--	689	654
XIII	N_2	Total energy	--	--	--	--	5,630	5,340
		Incremental	--	--	--	--	690	650
XIV	INC	Total energy	531	499	1,586	1,502	15,829	14,987
		Incremental	322	301	960	908	5,289	4,987

[a] CA = Carbon adsorber.
RF = Condensation-air refrigeration system.
N_2 = Condensation-nitrogen atmosphere system.
INC = Incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Baseline for Alternatives II and III.

[d] Energy requirements are for carbon adsorber used to control mix room emissions.

[e] Baseline for Alternatives V through XIV with CA or INC control.

[f] Baseline for Alternatives V through XIV with RF control.

[g] Baseline for Alternatives V through XIV with N_2 control.

TABLE 7-15. ESTIMATED 1990 NATIONAL ENERGY REQUIREMENTS FOR MAGNETIC TAPE COATING LINES

Reg. Alt.	Coating operation control device[a]	Electrical		Natural gas		Steam		Total	
		GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
I	None	0	0	0	0	0	0	0	0
I	None	0	0	0	0	0	0	0	0
III[c]	None	32	30	0	0	7,970	7,510	8,000	7,540
IV	CA	5,870	5,520	0	0	113,530	107,650	119,400	113,170
IV	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
IV	N_2	3,300	3,190	0	0	51,050	48,400	54,350	51,590
V	CA	5,870	5,520	0	0	116,390	110,400	122,260	115,920
V	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
VI	CA	5,870	5,520	0	0	113,530	107,650	119,400	113,170
VI	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
VI	N_2	3,300	3,190	0	0	51,050	48,400	54,350	51,590
VII	CA	5,870	5,520	0	0	116,390	110,400	122,260	115,920
VII	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
VIII	CA	5,870	5,520	0	0	120,950	114,690	126,820	120,210
VIII	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
VIII	N_2	3,300	3,190	0	0	51,050	48,400	54,350	51,590
IX	CA	5,880	5,530	0	0	121,500	115,180	127,380	120,710
IX	RF	41,580	39,490	0	0	58,630	55,550	100,210	95,040
IX	N_2	3,300	3,190	0	0	58,630	55,580	61,930	58,770
X	INC	1,610	1,500	173,000	163,770	0	0	174,610	165,270
XIA	CA	5,870	5,520	0	0	120,950	114,690	126,820	120,210
XIA	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
XIA	N_2	3,300	3,190	0	0	51,050	48,400	54,350	51,590
XIB	CA	5,880	5,530	0	0	124,410	117,930	130,290	123,460
XIB	RF	41,580	39,490	0	0	58,630	55,580	100,210	95,070
XII	INC	1,610	1,500	173,000	163,770	0	0	174,610	165,270
XIII	CA	5,880	5,530	0	0	128,800	122,210	134,680	127,740
XIII	RF	41,580	39,490	0	0	58,630	55,580	100,210	95,070
XIII	N_2	3,300	3,190	0	0	58,630	55,580	61,930	58,770
XIV	INC	1,620	1,510	173,000	163,770	7,970	7,510	182,590	172,790

[a] CA = Carbon adsorber.
RF = Condensation-air refrigeration system.
N_2 = Condensation-nitrogen atmosphere system.
INC = Incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Energy requirements are for carbon adsorber used to control mix room emissions.

7.7 REFERENCES FOR CHAPTER 7

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4. Compilation of Air Pollution Emission Factors. 3rd Edition. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. Publication No. 999-AP-42. April 1981. pp. 1.4-1 - 1.4-3.

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8. COSTS

8.1 COST ANALYSIS OF REGULATORY ALTERNATIVES

The estimated cost impacts of implementing the regulatory alternatives for the model lines described in Chapter 6 are presented in this chapter. The objective of this analysis is to quantify the cost impacts associated with various levels of control of VOC emissions. The economic impact of the regulatory alternatives on magnetic tape manufacturers is presented in Chapter 9.

Capital and annualized costs are presented for the uncontrolled line and for the pollution control devices for the regulatory alternatives. All costs are reported in March 1983 dollars.

8.1.1 New Lines

Three model line sizes (research, small, and typical) were selected to characterize the manufacturing and research operations expected to be constructed, modified, or reconstructed in the near future. A model line is defined as the combination of a model coating operation, a model mix room, and model solvent storage tanks. Model solvent storage tanks are defined as the number and size of tanks required to supply solvent to the model mix room to be used in coating preparation. (Throughout this chapter, model storage tank refers to these groups of tanks, not individual tanks.) A model mix room is defined as the mix equipment (i.e., mills, mixers, and holding tanks) required to supply coating to the magnetic tape coating operation. A model coating operation is defined as the combination of a coating application/flashoff area, a drying oven, and the necessary ancillary equipment.

The model solvent storage tank parameters, model mix room parameters, and model coating operation parameters for carbon adsorbers (or incinerators), condensers recovering cyclohexanone alone, and for condensers recovering solvent mixtures are presented in Tables 8-1 through 8-5. Table 8-6 shows the bases used for developing the capital and annualized cost estimates for the uncontrolled magnetic tape model lines and for the various control devices.

8.1.1.1 Capital and Annualized Costs of Model Lines. Tables 8-7 and 8-8 present the capital and annualized cost estimates for the uncontrolled model storage tanks and the model mix rooms and coating operations. The installed capital costs for uncontrolled storage tanks are based on equations from the EPA document, VOC Emissions From Volatile Organic Liquid Storage Tanks--Background Information for Proposed Standards.[1] The installed capital costs for the mix room equipment are based on vendor data. These cost estimates include the mixers, mills, holding tanks, and polishing tanks. The installed capital costs for the uncontrolled coating operation include the coater, associated oven, web unwinders and rewinders, and other ancillary equipment and are based on industry and vendor data. Building and land costs were also included in the capital cost estimates for model mix rooms and coating operations.

The annualized costs for solvent storage tanks are composed of maintenance and inspection fees, taxes, insurance, administration, and the annual capital charge. The annual capital charge is the cost associated with recovering the initial capital investment over the depreciable life of the equipment. The annual capital charge is calculated by multiplying the total installed capital cost by the capital recovery factor. The capital recovery factor is based on the depreciable life of the equipment and a 10 percent interest rate.

The annualized costs for the magnetic tape mix room and coating operation are composed of the sum of the annual operating and maintenance costs, plus the annualized capital charge. The operating costs include operating labor, supervision, raw materials, utilities, overhead, taxes, administration, and insurance. The land cost is not included in the capital recovery charge, instead it is multiplied by the interest rate to obtain the annual interest charge on the money invested in the land.

Tables 8-9 through 8-12 present the estimated total installed capital and annualized costs and annualized cost per unit area of tape coated for each of the model storage tank, mix room, and coating operation control device options. For comparison, the uncontrolled capital and annualized costs are also presented in the tables.

The control device capital costs include the control device itself, as well as auxiliary equipment such as ductwork, enclosures, and stacks, and the direct and indirect installation charges. The capital costs of pressure relief valves, conservation vents, fluidized-bed carbon adsorbers, disposable-canister carbon adsorbers, and condensers were obtained from vendor data. The fluidized-bed carbon adsorber and condensers can only be designed for the typical size model lines. The research and small line fixed-bed carbon adsorber capital costs are based on equations in an EPA study performed by GARD, Inc., and were verified by vendor quotes.[2] The typical model line fixed-bed carbon adsorber capital cost is based on vendor and industry data. Incinerator capital costs were determined using the GARD manual. The capital cost of enclosures was determined from industry data. The ductwork costs were obtained from the GARD manual and Richardson's Engineering Manual.[3-5]

The annualized control device costs are composed of annual operating, maintenance, and capital recovery charges. A charge was included for solvent waste removal based on discussions with solvent brokers regarding liquid waste removal charges. Credits for solvents recovered are based on recoveries of 90 percent of the potentially recoverable solvent. This allows for a 10 percent loss of solvent in distillation and dehydration systems. Only the typical size lines recover solvents. Based on industry and vendor data, 60 percent of the market value of the solvents was used to determine the credit. A credit was also given when conservation vents are used to reduce solvent emissions. In the case of incinerators, a heat recovery factor of 35 percent was allowed.

Tables 8-13 through 8-15 present the installed capital and annualized costs for each regulatory alternative for the research, small, and typical lines (combined storage tanks, mix room, and coating operation). The only control device evaluated for the solvent storage tank is the conservation vent since it is the most commonly used control device for storage tanks.

As shown in Table 8-13 through 8-15, the total annualized cost per unit area of tape coated decreases with increasing line size. This is because for a proportionately small increase in capital cost, a greater amount of tape can be coated, while the annualized costs remain proportionally the same. For the typical line, there is a large credit for solvent recovery, which further reduces the annualized cost per unit area.

8.1.1.2 Cost Effectiveness. The cost-effectiveness value is the annual cost to control one ton of VOC pollutant. The average cost-effectiveness value is the annualized cost per ton of pollutant required to implement a control system achieving greater VOC reduction than that which is most commonly being used presently (baseline). The average cost effectiveness of an alternative was determined by dividing the incremental annualized control system cost by the incremental annual VOC reduction. The incremental annual cost is the difference in the net annualized cost of the alternative compared to baseline. The incremental VOC reduction is the difference in the VOC reduction of the alternative compared to baseline.

The incremental cost effectiveness is a measure of the additional annual cost required to achieve the next higher level of emission reduction. The incremental cost effectiveness was calculated by dividing the incremental increase in the annual control device cost by the incremental emission reduction.

Table 8-16 presents the average cost-effectiveness values for each model solvent storage tank control option with respect to the uncontrolled baseline. The incremental cost-effectiveness values of the control options for model solvent storage tanks are shown in Table 8-17. As shown in Table 8-17, the incremental cost effectiveness ranges from $700/Mg ($670/ton) for conservation vent controlling emissions from a typical model line storage tank to $472,500/Mg ($420,000/ton) for a separate disposable carbon adsorber controlling emissions from small model storage tanks. [NOTE: The control options and costs for the solvent storage tanks have been revised. The new data are presented in Appendix F].

Table 8-18 presents the average cost effectiveness for each model mix room regulatory alternative with respect to the uncontrolled baseline. The incremental cost effectiveness of the regulatory alternative for model mix rooms is shown in Table 8-19. As shown in Table 8-19, the incremental cost-effectiveness values range from -$740/Mg (-$670/ton) for conservation vents controlling emissions from a typical model mix room to $6,900/Mg ($6,200/ton) for a common carbon adsorber controlling emissions from a research model mix room.

The average cost effectiveness of each regulatory alternative with respect to the uncontrolled baseline for model coating operations is presented in Table 8-20. Because some new plants may be located in ozone nonattainment areas, the average cost effectiveness of each regulatory alternative for coating operations has also been calculated with respect to Alternative IV, the controlled baseline based on the State implementation plans. These values are shown in Table 8-21.

The incremental cost effectiveness of each regulatory alternative for the model coating operation is shown in Table 8-22. The incremental cost effectiveness ranges from -$600/Mg (-$540/ton) for a condenser controlling emissions from a typical model coating operation using cyclohexanone to $18,100/Mg ($16,300/ton) for an incinerator controlling emissions from a research model coating operation.

Tables 8-23, 8-24, and 8-25 present the average cost effectiveness for each regulatory alternative with respect to uncontrolled (I) and controlled (IV) baselines for the research, small, and typical model lines, respectively. The incremental cost effectiveness for the regulatory alternatives is also presented in these tables. For incremental cost-effectiveness calculations, the same types of control devices were compared to each other. In cases where matching control devices did not occur, the fixed-bed carbon adsorber values for the alternative with lower emission reduction were used.

8.1.2 Modified/Reconstructed Facilities

Under the provisions of 40 CFR 60.14 and 60.15, an "existing facility" may become subject to standards of performance if it is deemed modified or reconstructed. In such situations, control devices may have to be installed for compliance with new source performance standards.

The cost for installing a control system on an existing facility may be greater than the cost of installing the control system on a new facility. Because retrofit costs are highly site-specific, they are difficult to estimate. The availability of space and the configuration of existing equipment in the plant are the major limiting site-specific factors.

8.2 OTHER COST CONSIDERATIONS

In addition to costs associated with the Clean Air Act, the magnetic tape coating industry may also incur costs as a result of other Federal rules or regulations. These impacts are discussed in this section.

8.2.1 Costs Associated with Increased Water Pollution and Solid Waste Disposal

Wastewater disposal problems arise from the use of fixed-bed carbon adsorption solvent recovery systems. Dissolved solvents in the condensate from the carbon adsorber represent the primary potential water pollutant. Based on typical stripper column design, the aqueous bottoms from the stripper column contains 100 ppm VOC.[8-8] This wastewater is usually disposed of in a municipal sewer system. The actual amount of any surcharges would be determined by local regulations. In any event, it is unlikely that such charges would be significant. The capital and annual costs of the stripper column with a wastewater VOC concentration of about 100 ppm have been included in the cost calculations for the typical line.

Solid waste consists of the spent carbon used in carbon adsorption systems. The carbon from fixed-bed and fluidized-bed carbon adsorbers is usually sold back to processors, reactivated, and then sold again to the original purchaser or to other carbon adsorber operators; therefore, there are no solid waste disposal costs associated with these systems. The cost of disposing of the carbon from the disposable canisters in a secure landfill was included in the annual cost.

8.2.2 Resource Conservation and Recovery Act

The liquid solvent wastes generated by the air pollution control devices associated with the magnetic tape industry are classified as hazardous or toxic under the provisions of the Resource Conservation and Recovery Act (RCRA). Charges for removal by solvent reclaimers were included in the annual operating costs.

8.2.3 Resource Requirements Imposed on State, Regional, and Local Agencies

The owner or operator of a magnetic tape coating plant is responsible for making application to the State for a permit to construct and subsequently to operate a new installation. The review of these applications, and any later enforcement action, would be handled by local, State, or regional regulatory agencies. Because it is expected that these plants will be distributed throughout the United States instead of clustered in one State and that they will be added primarily in States already having magnetic tape coating plants, the promulgation of standards for magnetic tape coating plants should not impose major resource requirements on the regulatory agencies. Any costs incurred are not expected to limit the financial ability of these plants to comply with the proposed NSPS.

TABLE 8-1. MODEL SOLVENT STORAGE TANK PARAMETERS

Line designation:	Research	Small	Typical
Solvent usage, m^3/yr (gal/yr)	23 (6,130)	70 (18,400)	700 (184,000)
No. of different solvents used	5	3	3
No. of storage tanks	5	3	3
Capacity of each tank, m^3 (gal)	4 (1,000)	4 (1,000)	40 (10,000)
Emissions, Mg/yr (ton/yr)	0.03 (0.04)	0.05 (0.05)	0.39 (0.43)

TABLE 8-2. MODEL MIX ROOM PARAMETERS

Line designation:	Research	Small	Typical
1. Line information			
Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)
Line speed, m/s, (ft/min)	1.3 (250)	1.3 (250)	2.5 (500)
Operating, h/yr	2,000	6,000	6,000
2. Mix room information			
Coating prepared, m^3/d (gal/d)	0.13 (35)	0.26 (70)	2.6 (675)
Solvent used, m^3/d (gal/d)	0.11 (30)	0.21 (55)	2.1 (550)
Equipment, number of:			
Mixers	2	2	2
Mills[a]	1	1	1
Holding tanks	1	2	2
Polishing tanks	1	2	2
Equipment ventilation rate per tank, m^3/h (acfh)[b]	5.7 (200)	5.7 (200)	5.7 (200)
Uncontrolled VOC emissions, Mg/yr (tons/yr)	2.7 (3)	7.3 (8)	71 (78)

[a] There are no VOC emissions from the sealed mills.

[b] For systems purging tanks and ducting emissions to control device.

TABLE 8-3. MODEL COATING OPERATION PARAMETERS FOR CARBON ADSORBER OR INCINERATOR CONTROL OPTIONS

Line designation:	Research	Small	Typical
1. Line information			
Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)
Line speed, m/s (ft/min)	1.3 (250)	1.3 (250)	2.5 (500)
Operating, h/yr	2,000	6,000	6,000
2. Process information			
Coating thickness, wet, μm^a (mil)^b	25 (1)	25 (1)	25 (1)
Coating formulation:			
% VOC, weight	63	63	63
Density, kg/m^3 (lb/gal)	1,200 (10)	2,300 (10)	1,200 (10)
Solvent mixture	Tetrahydrofuran (20%) Methyl ethyl ketone (20%) Methyl isobutyl ketone (20%) Toluene (20%) Cyclohexanone (20%)	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)
Coating head area ventilation rate, Partial enclosure, m^3/s (ft^3/min)	0.15 (310)	0.15 (310)	0.25 (525)
Total enclosure, m^3/s (ft^3/min)	0.14 (300)	0.14 (300)	0.24 (500)
Oven ventilation rate, m^3/s, actual	0.28	0.28	2.8
standard^c	0.26	0.26	2.6
(ft/min), actual	(600)	(600)	(6,000)
standard^c	(550)	(550)	(5,500)

(continued)

TABLE 8-3. (continued)

Line designation:	Research	Small	Typical
Oven temperature, K (°F)	355 (180)	355 (180)	355 (180)
Carbon adsorber inlet temperature, K (°F)	311 (100)	311 (100)	311 (100)
Incinerator heat exchanger inlet temperature, K (°F)	344 (160)	344 (160)	344 (160)
Solvent concentration in exhaust: % LEL	25	25	25
ppmV	~2,500	~2,500	~2,500
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)	23 (25)	68 (75)	635 (700)

[a] μm = micrometer.
[b] mil = 0.001 inch.
[c] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.

TABLE 8-4. MODEL COATING OPERATION PARAMETERS FOR CONDENSERS RECOVERING CYCLOHEXANONE

Line designation:	Research	Small	Typical
1. Line information			
Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)
Line speed, m/s (ft/min)	1.27 (250)	1.27 (250)	2.54 (500)
Operating, h/yr	2,000	6,000	6,000
2. Process information			
Coating thickness, wet, µm[a] (mil)[b]	25 (1)	25 (1)	25 (1)
Coating formulation:			
% VOC, weight	63	63	63
% VOC, volume	80	80	80
Density, kg/m^3 (lb/gal)	1,200 (10)	1,200 (10)	1,200 (10)
Solvent mixture	Cyclohexanone (100%)	Cyclohexanone (100%)	Cyclohexanone (100%)
Coating head area ventilation rate,			
Total enclosure, m^3/s (ft^3/min)	0.14 (300)	0.14 (300)	0.24 (500)
Partial enclosure m^3/s (ft^3/min)	0.15 (310)	0.15 (310)	0.25 (525)
Oven ventilation rate,			
System A			
m^3/s, actual	0.18	0.18	1.75
standard[d]	0.16	0.16	1.6
(ft^3/min), actual	(370)	(370)	(3,700)
standard[d]	(340)	(340)	(3,400)

(continued)

TABLE 8-4. (continued)

Line designation:	Research	Small	Typical
System B[e]			
m^3/s, actual			1.65
standard[d]			1.42
(ft^3/min), actual			(3,500)
standard[d]			(3,000)
Oven temperature, K (°F)	355 (180)	355 (180)	355 (180)
Control device inlet temperature, K (°F)	344 (160)	344 (160)	344 (160)
Solvent concentration in exhaust:			
System A: % LEL	40	40	40
ppmV	~4,000	~4,000	~4,000
System B: % vol. solvent	10	10	10
nitrogen			
atmosphere			
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)	23 (25)	68 (75)	635 (700)

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[a] μm = micrometer.
[b] mil = 0.001 inches.
[c] Applicable to System A only.
[d] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.
[e] Volume sent to condensation module; systems cannot be designed for the research and small coating operations.

TABLE 8-5. MODEL COATING OPERATION PARAMETERS FOR CONDENSERS RECOVERING SOLVENT MIXTURES

Line designation:	Research	Small	Typical
1. Line information			
Web width, m (in.)	0.15 (6)	0.15 (6)	0.66 (26)
Line speed, m/s (ft/min)	1.27 (250)	1.27 (250)	2.54 (500)
Operating, h/yr	2,000	6,000	6,000
2. Process information			
Coating thickness, wet, µm[a] (mil)[b]	25 (1)	25 (1)	25 (1)
Coating formulation:			
% VOC, weight	63	63	63
% VOC, volume	80	80	80
Density, kg/m^3 (lb/gal)	1,200 (10)	1,200 (10)	1,200 (10)
Solvent mixture	Tetrahydrofuran (20%) Methyl ethyl ketone (20%) Methyl isobutyl ketone (20%) Toluene (20%) Cyclohexanone (20%)	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)	Tetrahydrofuran (40%) Toluene (40%) Cyclohexanone (20%)
Coating head area ventilation rate			
Total enclosure, m^3/s (ft^3/min)	0.14 (300)	0.14 (300)	0.24 (500)
Partial enclosure, m^3/s (ft^3/min)	0.15 (310)	0.15 (310)	0.25 (525)
Oven ventilation rate, System A			
m^3/s, actual	0.18	0.18	1.75
standard[d]	0.16	0.16	1.6
(ft^3/min), actual	(370)	(370)	(3,700)
standard[d]	(340)	(340)	(3,400)

(continued)

TABLE 8-5. (continued)

Line designation:	Research	Small	Typical
System B[e]			
m^3/s, actual			1.65
standard[d]			1.42
(ft^3/min), actual			(3,500)
standard			(3,000)
Oven temperature, K (°F)	355 (180)	355 (180)	355 (180)
Control device inlet temperature, K (°F)	344 (160)	344 (160)	344 (160)
Solvent concentration in exhaust:			
System A: % LEL	40	40	40
ppmV	~4,000	~4,000	~4,000
System B: % vol. solvent nitrogen atmosphere	10	10	10
Uncontrolled VOC emissions from coating operation, Mg/yr (tons/yr)	23 (25)	68 (75)	635 (700)

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[a] μm = micrometer.

[b] mil = 0.001 inches.

[c] Applicable to System A only.

[d] Standard conditions are 20°C (68°F) and 1 atmosphere pressure.

[e] Volume sent to condensation module; systems cannot be designed for the research and small coating operations.

TABLE 8-6. BASES FOR ESTIMATING CAPITAL AND ANNUALIZED COSTS OF MAGNETIC TAPE COATING MODEL LINES

Cost element	Cost, dollar per unit specified
1. Capital costs	
• Solvent storage tank installed cost[9]	$(0.883\ V^{0.577})(1.25)(1.04)(1{,}000)$[a]
• Mix equipment[b]	
• Coating operation (unwind through rewind) installed cost[b]	
• Mix room purchased equipment (1.18 times equipment cost)[10]	
• Mix room installed cost (30% times purchased equipment cost)[11]	
• Coating operation purchased equipment (total installed cost ÷ 1.35)[12]	
• Building cost (29% times the purchased equipment cost)[13]	
• Land cost (6% times the purchased equipment cost)[13]	
• Fluidized-bed carbon adsorber installed cost[b]	
• Nitrogen condensation system installed cost[b]	
• Fixed-bed carbon adsorber installed cost[b]	
• Total and partial enclosure installed cost[b]	
2. Direct operating costs	
• Labor	
--Operator[14]	7.04/h
--Supervisory (15% of total operator annual cost)[15]	
• Raw material[b]	
--Polyester film	$0.22/m^2$ $(0.02/ft^2)$
--Solvents: blend	1.15/ℓ (4.35/gal)
cyclohexanone	1.20/ℓ (4.55/gal)
--Magnetic materials	4.48/kg (2.03/lb)
--Resins	5.29/kg (2.40/lb)
--Activated carbon	3.86/kg (1.75/lb)
--Nitrogen	140/Mg (127/ton)

(continued)

TABLE 8-6. (continued)

Cost element	Cost, dollar per unit specified
• Maintenance (replacement parts and supplies)	
--Labor[14,15]	7.74/h
--Parts[15]	Equals labor
• Utilities	
--Electricity[16]	0.015/MJ (0.054/kWh)
--Gas[16]	0.114/m^3 (3.24/1,000 ft^3)
--Steam[15,16]	17.5/Mg (7.95/1,000 lb)
--Water[15,16]	0.033/m^3 (0.124/1,000 gal)
3. Indirect operating costs[15]	
• Overhead (80% of the sum of operating, supervisory, and maintenance labor)	
• Taxes (1% of capital cost)	
• Insurance (1% of capital cost)	
• Administration (2% of capital cost)	
• Capital recovery cost (11.746% for coating line equipment)[c]	
• Capital recovery cost (16.275% for control equipment)[d]	

[a] V = volume in m^3.

[b] Based on vendor and industry data.

[c] Based on 10 percent interest for 20-year life.

[d] Based on 10 percent interest for 10-year life.

TABLE 8-7. CAPITAL AND ANNUALIZED COSTS OF SOLVENT STORAGE TANKS[17]
(CONTROL OPTION 1--UNCONTROLLED)

Cost element	Line size		
	Research	Small	Typical
1. Capital costs			
• Total installed costs	$12,500	$7,500	$28,200
2. Direct operating costs			
• Maintenance	$625	$375	$1,410
• Inspection	125	75	282
• Total directs	$750	$450	$1,692
3. Indirect operating costs			
• Taxes, insurance, administration	$500	$300	$1,128
• Capital recovery cost (11.746% of capital costs)	1,468	881	3,313
• Total indirects	$1,968	$1,181	$4,441
4. TOTAL ANNUALIZED COSTS	$2,700	$1,600	$6,100

TABLE 8-8. (continued)

Cost element	Line size		
	Research	Small	Typical
• Insurance (1% of capital costs)[d]	12,475	12,516	29,316
• Administration (2% of capital costs)[d]	24,951	25,032	58,632
• Capital recovery cost (11.746% of capital costs)[d,e]	146,536	147,007	344,346
• Total indirects	$227,298	$333,468	$598,007
4. TOTAL ANNUALIZED COSTS	$670,638	$1,722,705	$11,108,955[b] 11,145,675[c]

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[a] Total installed cost of coating line, including indirect and direct installation costs.

[b] Raw material cost when using blend of cyclohexanone, toluene, and tetrahydrofuran.

[c] Raw material cost when using cyclohexanone.

[d] Total installed capital cost excluding land. Based on 10 percent interest for 20-year life.

[e] Excludes interest on land.

TABLE 8-8. CAPITAL AND ANNUALIZED COSTS OF MODEL MIX ROOMS AND COATING OPERATIONS[17] (CONTROL OPTION 1--UNCONTROLLED)

Cost element	Line size		
	Research	Small	Typical
1. Capital costs			
• Mix room equipment	$51,141	$53,666	$239,304
• Mix room installation	15,342	16,100	71,791
• Coating line[a]	960,000	960,000	2,100,000
• Common building costs	221,053	221,785	520,509
• Common land costs	45,735	45,887	107,691
• Total installed costs	$1,293,271	$1,297,438	$3,039,295
2. Direct operating costs			
• Labor			
--Operator	$28,160	$126,720	$126,720
--Supervisory	4,224	19,008	19,008
• Raw material	381,242	1,141,923	10,213,234[b] 10,249,954[c]
• Maintenance			
--Labor	6,192	24,768	24,768
--Parts	6,192	24,768	24,768
• Utilities			
--Electricity	11,450	34,400	84,800
--Steam	5,880	17,650	17,650
• Total directs	$443,340	$1,389,237	10,510,948[b] $10,547,668[c]
3. Indirect operating costs			
• Overhead (80% of the sum of operating, supervisory, and maintenance labor)	$30,861	$136,397	$136,397
• Taxes (1% of capital costs)[d]	12,475	12,516	29,316

(continued)

TABLE 8-9. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR MODEL SOLVENT STORAGE TANK CONTROL OPTIONS[17]*

Cost item	Uncontrolled	Control options		
		Conservation vents	Separate disposable carbon adsorbers[a]	Common fixed-bed carbon adsorbers[b]
1. Research				
• Total installed capital cost				
--Storage tanks	$12,500	$12,500	$12,500	$12,500
--Control system (including ductwork)	N/A	1,700	38,400	31,400
--Total	$12,500	$14,200	$50,900	$43,900
• Total annualized costs				
--Storage tanks	$2,700	$2,700	$2,700	$2,700
--Control system	N/A	350	7,800	6,400
--Credit/debit for solvent[c]	N/A	-10	70	0
--Total	$2,700	$3,040	$10,570	$9,100
• Total annualized operating cost per unit area coated,[d] ¢/m^2 (¢/ft^2)	0.23 (0.022)	0.26 (0.024)	0.91 (0.085)	0.78 (0.073)
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	0.029 (0.003)	0.68 (0.06)	0.55 (0.051)
2. Small				
• Total installed capital cost				
--Storage tanks	$7,500	$7,500	$7,500	$7,500
--Control system (including ductwork)	N/A	1,000	23,000	25,000
--Total	$7,500	$8,500	$30,500	$32,500

(continued)

TABLE 8-9. (continued)

Cost item	Control options Uncontrolled	 Conservation vents	 Separate disposable carbon adsorbers[a]	 Common fixed-bed carbon adsorbers[b]
• Total annualized costs				
--Storage tanks	$1,600	$1,600	$1,600	$1,600
--Control system	N/A	210	4,700	5,100
--Credit/debit for solvent[c]	N/A	-15	115	0
--Total	$1,600	$1,795	$6,415	$6,700
• Total annualized cost per unit area coated,[e] ¢/m^2 (¢/ft^2)	0.046 (0.004)	0.052 (0.005)	0.18 (0.017)	0.19 (0.018)
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	0.006 (0.0005)	0.13 (0.012)	0.15 (0.014)
3. Typical				
• Total installed capital cost				
--Storage tanks	$28,200	$28,200	$28,200	$28,200
--Control system (including ductwork)	N/A	1,000	26,900	25,000
--Total	$28,200	$29,200	$55,100	$53,200
• Total annualized costs				
--Storage tanks	$6,100	$6,100	$6,100	$6,100
--Control system	N/A	210	5,400	5,100
--Credit/debit for solvent[c]	N/A	-100	380	-300
--Total	$6,100	$6,210	$11,880	$10,900

(continued)

TABLE 8-9. (continued)

Cost item	Control options			
	Uncontrolled	Conservation vents	Separate disposable carbon adsorbers[a]	Common fixed-bed carbon adsorbers[b]
• Total annualized operating cost per unit area coated,[f] ¢/m^2 (¢/ft^2)	0.018 (0.002)	0.018 (0.002)	0.034 (0.003)	0.031 (0.003)
• Total annualized control system cost per unit area coated,[f] ¢/m^2 (¢/ft^2)	N/A	0.0003 (0.0000)	0.02 (0.002)	0.014 (0.001)

N/A = Not applicable.

[a] A disposable-canister carbon adsorber controls the VOC emissions from the storage tanks only.

[b] VOC emissions from the storage tanks plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

[c] Negative values are credits for solvent recovery and reuse, based on a distillation efficiency of 90 percent. For conservation vents, credit given for solvent "saved" from escaping into the atmosphere.

[d] Total area coated annually is 11.6 x10^5 m^2 (12.5 x10^6 ft^2) [= (5 in.)(250 ft/min)(12 in./ft)(60 min/h) (2,000 h/yr)].

[e] Total area coated annually is 34.84 x10^5 m^2 (37.5 x10^6 ft^2) [= (5 in.)(250 ft/min)(12 in./ft)(60 min/h) (6,000 h/yr)].

[f] Total area coated annually is 34.84 x10^6 m^2 (375.0 x10^6 ft^2) [= (25 in.)(500 ft/min) (12 in./ft) (60 min/h) (6,000 h/yr)].

*The control options and costs for storage tanks have been revised. See Tables F-2 and F-6 through F-10 in Appendix F for these revisions.

TABLE 8-10. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR MODEL MIX ROOM CONTROL OPTIONS[17]

Cost item	Regulatory Alternatives			
	I (Uncontrolled)	II (Covers)	III (Separate disposable carbon adsorbers)[a]	IX (Common fixed-bed carbon adsorbers)[b]
1. Research				
• Total installed capital cost				
--Mix room equipment[c]	$84,400	$84,400	$84,400	$84,400
--Control system (including ductwork)	N/A	2,700	35,300	3,500[d]
--Total	$84,400	$87,100	$119,700	$87,900
• Total annualized costs				
--Mix room equipment	$13,800	$13,800	$13,800	$13,800
--Control system	N/A	560	12,000	900
--Credit/debit for solvent[e]	N/A	-830	150	150
--Total	$13,800	$13,530	$25,950	$14,850
• Total annualized operating cost per unit area coated,[f] ¢/m² (¢/ft²)	1.19 (0.11)	1.17 (0.11)	2.24 (0.21)	1.28 (0.12)
• Total annualized control system cost per unit area coated, ¢/m² (¢/ft²)	N/A	-0.023 (-0.002)	1.05 (0.10)	0.09 (0.01)
2. Small				
• Total installed capital cost				
--Mix room equipment[c]	$88,500	$88,500	$88,500	$88,500
--Control system (including ductwork)	N/A	4,100	36,600	4,700[d]
--Total	$88,500	$92,600	$125,100	$93,200

(continued)

TABLE 8-10. (continued)

Cost item	Regulatory Alternatives			
	I (Uncontrolled)	II (Covers)	III (Separate disposable carbon adsorbers)[a]	IX (Common fixed-bed carbon adsorbers)[b]
• Total annualized costs				
--Mix room equipment	$15,800	$15,800	$15,800	$15,800
--Control system	N/A	840	22,400	1,600
--Credit/debit for solvent[e]	N/A	-2,200	400	400
--Total	$15,800	$14,440	$38,600	$17,800
• Total annualized operating cost per unit area coated,[g] ¢/m^2 (¢/ft^2)	0.45 (0.04)	0.41 (0.04)	1.11 (0.10)	0.51 (0.05)
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	-0.04 (-0.004)	0.65 (0.06)	0.06 (0.005)
3. Typical				
• Total installed capital cost				
--Mix room equipment[c]	$394,900	$394,900	$394,900	$394,900
--Control system (including ductwork)	N/A	4,100	36,600	4,700[d]
--Total	$394,900	$399,000	$431,500	$399,600
• Total annualized costs				
--Mix room equipment	$81,300	$81,300	$81,300	$81,300
--Control system	N/A	840	26,200	6,500
--Credit/debit for solvent[e]	N/A	-21,600	3,900	-46,200
--Total	$81,300	$60,540	$111,400	$41,600
• Total annualized operating cost per unit area coated,[h] ¢/m^2 (¢/ft^2)	0.23 (0.02)	0.17 (0.02)	0.32 (0.03)	0.12 (0.01)

(continued)

TABLE 8-10. (continued)

	Regulatory Alternatives			
Cost item	I (Uncontrolled)	II (Covers)	III (Separate disposable carbon adsorbers)[a]	IX (Common fixed-bed carbon adsorbers)[b]
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	-0.06 (-0.0055)	0.09 (0.008)	-0.11 (-0.011)

N/A = Not applicable.

[a] A fixed-bed carbon adsorber controls the VOC emissions from the mix room only.

[b] VOC emissions from the mix room plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

[c] Total installed capital cost including land and building costs.

[d] Incremental costs result from control of mix room equipment by coating operation control device, for these regulatory alternatives.

[e] Negative values are credits for solvent recovery and reuse, based on distillation efficiency of 90 percent. For conservation vents, credit given for solvent "saved" from escaping into the atmosphere.

[f] Total area coated annually is 11.6 $\times 10^5$ m^2 (12.5 $\times 10^6$ ft^2) [= (5 in.)(250 ft/min)(12 in./ft)(60 min/h)(2,000 h/yr)].

[g] Total area coated annually is 34.84 $\times 10^5$ m^2 (37.5 $\times 10^6$ ft^2) [= (5 in.)(12 in./ft)(250 ft/min)(60 min/h)(6,000 h/yr)].

[h] Total area coated annually is 34.84 $\times 10^6$ m^2 (375.0 $\times 10^6$ ft^2) [≐ (25 in.)(12 in./ft)(500 ft/min)(60 min/h)(6,000 h/yr)].

TABLE 8-11. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR MODEL COATING OPERATIONS USING CARBON ADSORBERS OR INCINERATORS[17]

Cost item Regulatory Alternative:	Uncon-trolled	Fixed-bed carbon adsorbers			Fluidized-bed carbon adsorbers			Incinerator
	I	IV[a]	V[b]	VIII[c]	IV[a]	V[b]	VIII[c]	X
Research								
• Installed capital cost								
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	Control device cannot be designed for this size coating operation.			1,208,900
--Control system (including ductwork)	N/A	129,200	136,800	145,200				228,700
--Total	1,208,900	1,338,100	1,345,700	1,354,100				1,437,600
• Annualized costs								
--Coating operation equipment	661,500	661,500	661,500	661,500				661,500
--Control system	N/A	32,700	34,300	36,200				53,700
--Credit/debit for solvent	N/A	1,100	1,200	1,200				N/A
Total	661,500	695,300	697,000	698,900				715,200
• Total annualized operating costs[e], ¢/m^2 (¢/ft^2)	57.0 (5.3)	59.9 (5.6)	60.1 (5.6)	60.3 (5.6)				61.7 (5.7)
• Annual operating cost of control system, $	N/A	33,800	35,500	37,400				53,700
¢/m^2 (¢/ft^2)[e]	N/A	2.9 (0.27)	3.1 (0.28)	3.2 (0.30)				4.6 (0.43)
Small								
• Installed capital cost								
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	Control device cannot be designed for this size coating operation.			1,208,900
--Control system (including ductwork)	N/A	131,600	139,300	147,700				228,700
--Total	1,208,900	1,340,500	1,348,200	1,356,600				1,437,600
• Annualized costs								
--Coating operation equipment	1,711,500	1,711,500	1,711,500	1,711,500				1,711,500
--Control system	N/A	44,800	46,600	49,000				67,500
--Credit/debit for solvent	N/A	3,300	3,400	3,700				N/A
--Total	1,711,500	1,759,600	1,761,500	1,764,200				1,779,000
• Total annualized operating costs[f] ¢/m^2 (¢/ft^2)	49.1 (4.6)	50.6 (4.7)	50.6 (4.7)	50.6 (4.7)				50.6 (4.7)
• Annual operating cost of control system, $	N/A	48,100	50,000	52,700				67,500
¢/m^2 (¢/ft^2)[f]	N/A	1.4 (0.13)	1.4 (0.13)	1.51 (0.14)				1.94 (0.18)

(continued)

TABLE 8-11. (continued)

Cost item	Regulatory Alternative:	Uncon-trolled I	Fixed-bed carbon adsorbers IV[a]	V[b]	VIII[c]	Fluidized-bed carbon adsorbers IV[a]	V[b]	VIII[c]	Incinerator X
Typical									
• Installed capital cost									
--Coating operating equipment[d]		2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400
--Control system (including ductwork)		N/A	1,580,000	1,600,000	1,607,200	1,759,200	1,774,700	1,784,000	300,300
--Total		2,644,400	4,224,400	4,244,400	4,251,600	4,403,600	4,419,100	4,428,400	2,944,700
• Annualized costs									
--Coating operation equipment		11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400
--Control system		N/A	414,400	420,600	425,000	467,900	471,100	473,000	153,500
--Credit/debit for solvent[g]		N/A	-362,400	-379,800	-406,100	-362,400	-379,800	-406,000	N/A
--Total		11,038,400	11,090,400	11,079,200	11,057,300	11,143,900	11,129,700	11,105,300	11,191,900
• Total annual operating costs[h], ¢/m² (¢/ft²)		31.68 (2.94)	31.83 (2.96)	31.80 (2.95)	31.74 (2.95)	31.99 (2.97)	31.94 (2.97)	31.88 (2.96)	32.12 (2.98)
• Annual operating cost of control system, $		N/A	52,000	40,800	18,900	105,500	81,300	66,900	153,500
¢/m² (¢/ft²)[h]		N/A	0.15 (0.01)	0.12 (0.011)	0.054 (0.005)	0.30 (0.028)	0.26 (0.024)	0.19 (0.018)	0.44 (0.041)

N/A = Not applicable.

[a] Control of oven emissions only.

[b] Partial enclosure over coating application/flashoff area.

[c] Total enclosure over coating application/flashoff area.

[d] Includes land and building costs.

[e] Area coated annually is 11.6 $\times 10^5$ m² (12.5 $\times 10^6$ ft²).

[f] Area coated annually is 34.84 $\times 10^5$ m² (37.5 $\times 10^6$ ft²).

[g] Negative values are credits for reuse of solvent, based on a distillation efficiency of 90 percent.

[h] Area coated annually is 34.84 $\times 10^6$ m² (375 x 10^6 ft²).

TABLE 8-12. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR MODEL COATING OPERATIONS USING CONDENSERS[17]

Cost item		Nitrogen condenser[a]		
Regulatory Alternative:	(Blend) IV[b]	(Blend) VIII[c]	(Cyclohexanone) IV[b]	(Cyclohexanone) VIII[c]
Typical				
• Installed capital cost				
--Coating operating equipment	2,644,400	2,644,400	2,644,400	2,644,400
--Control system (including ductwork)	1,102,600	1,117,300	733,000	747,700
--Total	3,747,000	3,761,700	3,377,400	3,392,100
• Annualized costs				
--Coating operation equipment	11,038,400	11,038,400	11,075,100	11,075,100
--Control system	279,200	282,200	188,700	191,600
--Credit/debit for solvent[d]	-362,400	-406,100	-378,200	-423,800
--Total	10,955,200	10,914,500	10,885,600	10,842,900
• Total annual operating costs[e], ¢/m^2 (¢/ft^2)	31.4 (2.9)	31.3 (2.9)	31.2 (2.9)	31.1 (2.9)
• Annual operating cost of control equipment,[e] $	-83,200	-123,900	-189,500	-232,200
¢/m^2 (¢/ft^2)	-0.24 (-0.022)	-0.36 (-0.033)	-0.54 (-0.050)	-0.67 (-0.062)

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[a] The system cannot be designed for operations the size of the research and small model coating operations. The nitrogen condenser system is a closed-loop N_2 circulation system; therefore, Regulatory Alternative V with a partial enclosure cannot be applied to this system.

[b] Control of oven emissions only.

[c] Total enclosure over coating application/flashoff area.

[d] Negative value indicates credit for reuse of recovered solvents, based on a distillation efficiency of 90 percent.

[e] Area coated annually is 34.84 x10^6 m^2 (375 [illegible]^6 ft^2).

TABLE 8-13. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR RESEARCH MODEL LINES FOR EACH REGULATORY ALTERNATIVE[a,17]

Cost item / Regulatory Alternatives:	I	II	III	IV	V	VI	VII	VIII	IX (Separate F1-CA)[b]	IX (Common F1-CA)[c]
• Installed capital cost, $										
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900
--Mix room equipment[d]	84,400	84,400	84,400	84,400	84,400	84,400	84,400	84,400	84,400	84,400
--Solvent storage tanks	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
--Coating operation control system	N/A	N/A	N/A	129,200	136,800	129,200	136,800	145,200	129,200	129,200
--Mix room control system	N/A	2,700	35,300	N/A	N/A	2,700	2,700	N/A	35,300	3,500
--Solvent storage tank control system*	N/A	1,700	N/A	N/A	1,700	1,700	1,700	1,700	1,700	1,700
--Total	1,305,800	1,310,200	1,342,800	1,435,000	1,444,300	1,439,400	1,447,000	1,452,700	1,472,000	1,440,200
• Annualized costs, $										
--Coating operation equipment	661,500	661,500	661,500	661,500	661,500	661,500	661,500	661,500	661,500	661,500
--Mix room equipment	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800
--Solvent storage tanks	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700
--Coating operation control system	N/A	N/A	N/A	32,700	34,300	32,700	34,300	36,200	32,700	32,700
--Mix room control system	N/A	600	12,000	N/A	N/A	600	600	N/A	12,000	900
--Solvent storage tank control system*	N/A	400	400	N/A	400	400	400	400	400	400
--Credit/debit for solvent[e]	N/A	-800	100	1,100	1,200	300	400	1,200	1,200	1,200
--Total	678,000	678,200	690,500	711,800	713,900	712,000	713,700	715,800	724,300	713,200
•Total annualized operating costs,[f] ¢/m² (¢/ft²)										
--Coating operation	57.03 (5.30)	57.03 (5.30)	57.03 (5.30)	59.9 (5.60)	60.1 (5.60)	59.9 (5.60)	60.1 (5.60)	60.26 (5.60)	59.9 (5.60)	59.9 (5.60)
--Mix room	1.19 (0.11)	1.17 (0.11)	2.24 (0.21)	(1.19) (0.11)	1.19 (0.11)	1.17 (0.11)	1.17 (0.11)	1.19 (0.11)	2.24 (0.21)	1.28 (0.12)
--Solvent storage tanks*	0.23 (0.02)	0.26 (0.02)	0.26 (0.02)	0.23 (0.02)	0.26 (0.02)	0.26 (0.02)	0.26 (0.02)	0.26 (0.02)	0.26 (0.02)	0.26 (0.02)
--Total	58.45 (5.43)	58.46 (5.43)	59.53 (5.53)	61.32 (5.73)	61.55 (5.73)	61.33 (5.73)	61.53 (5.73)	61.71 (5.73)	62.40 (5.83)	61.44 (5.74)
• Annualized control system costs										
--Coating operation, $	N/A	N/A	N/A	33,800	35,500	33,800	35,500	37,400	33,800	33,800
--Mix room, $	N/A	-300	12,200	N/A	N/A	-300	-300	N/A	12,200	1,000
--Solvent storage tanks, $*	N/A	300	300	N/A	300	300	300	300	300	300
--Total, $	N/A	0	12,500	33,800	35,800	33,800	35,500	37,700	46,300	35,100
--Total cost per unit area,[f] ¢/m² (¢/ft²)	N/A	0	1.08 (0.10)	2.91 (0.27)	3.09 (0.29)	2.91 (0.27)	3.06 (0.28)	3.25 (0.30)	3.99 (0.37)	3.03 (0.28)

(continued)

TABLE 8-13. (continued)

Cost item / Regulatory Alternatives:	X	XIA	XIB (Separate Fi-CA)[b]	XIB (Common Fi-CA)[c]	XII	XIII (Separate Fi-CA)[b]	XIII (Common Fi-CA)[c]	XIV
• Installed capital cost, $								
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900
--Mix room equipment[d]	84,400	84,400	84,400	84,400	84,400	84,400	84,400	84,400
--Solvent storage tanks	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
--Coating operation control system	228,700	145,200	136,800	136,800	228,700	145,200	145,200	228,700
--Solvent storage tank control system*	N/A	2,700	35,300	3,500	2,700	35,300	3,500	35,300
	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
--Total	1,536,200	1,455,400	1,479,600	1,447,800	1,538,900	1,488,000	1,456,200	1,571,500
• Annualized costs, $								
--Coating operation equipment	661,500	661,500	661,500	661,500	661,500	661,500	661,500	661,500
--Mix room equipment	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800
--Solvent storage tanks	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700
--Coating operation control system	53,700	36,200	34,300	34,300	53,700	36,200	36,200	53,700
--Mix room control system	N/A	600	12,000	900	600	12,000	900	12,000
--Solvent storage tank control system*	400	400	400	400	400	400	400	400
--Credit/debit for solvent[e]	N/A	400	1,300	1,300	-800	1,300	1,300	100
--Total	732,100	715,600	726,000	714,900	731,900	727,900	716,800	744,200
•Total annualized operating costs,[f] ¢/m² (¢/ft²)								
--Coating operation	61.7	60.26	60.26	60.26	61.7	60.26	60.26	61.7
	(5.70)	(5.60)	(5.60)	(5.60)	(5.70)	(5.60)	(5.60)	(5.70)
--Mix room	1.19	1.17	2.24	1.28	1.17	2.24	1.28	2.24
	(0.11)	(0.11)	(0.21)	(0.12)	(0.11)	(0.21)	(0.12)	(0.21)
--Solvent storage tanks*	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
--Total	63.15	61.69	62.76	61.80	63.13	62.76	61.80	64.2
	(5.83)	(5.73)	(5.83)	(5.74)	(5.83)	(5.83)	(5.74)	(5.93)
• Annualized control system costs, $								
--Coating operation	53,700	37,400	35,500	35,500	53,700	37,400	37,400	53,700
--Mix room	N/A	-300	12,200	1,100	-300	12,200	1,000	12,200
--Solvent storage tanks*	300	300	300	300	300	300	300	300
--Total	54,000	37,400	48,000	36,800	53,700	49,900	38,700	66,200
--Total cost per unit area,[f] ¢/m² (¢/ft²)	4.66	3.22	4.14	3.17	4.63	4.30	3.34	5.71
	(0.43)	(0.30)	(0.38)	(0.29)	(0.43)	(0.40)	(0.31)	(0.53)

N/A = Not applicable.

[a] Regulatory alternatives are defined in Table 6-10.

[b] A fixed-bed carbon adsorber (Fi-Ca) controls the VOC emissions from the mix room only.

[c] VOC emissions from the mix room plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber (Fi-CA).

[d] Includes land and building costs.

[e] Negative values are credits for solvent "saved" from escaping into the atmosphere by conservation vents.

[f] Area coated annually is 11.6×10^5 m² (12.5×10^6 ft²).

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-10 in Appendix F for these revisions.

TABLE 8-14. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR SMALL MODEL LINES FOR EACH REGULATORY ALTERNATIVE[a],17

Regulatory Alternatives: Cost item	I	II	III	IV	V	VI	VII	VIII	IX (Separate FI-CA)[b]	IX (Common FI-CA)[c]
• Installed capital cost, $										
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900
--Mix room equipment[d]	88,500	88,500	88,500	88,500	88,500	88,500	88,500	88,500	88,500	88,500
--Solvent storage tanks	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
--Coating operation control system	N/A	N/A	N/A	131,600	139,300	131,600	139,300	147,700	131,600	131,600
--Mix room control system	N/A	4,100	36,600	N/A	N/A	4,100	4,100	N/A	36,600	4,700
--Solvent storage tank control system*	N/A	1,000	1,000	N/A	1,000	1,000	1,000	1,000	1,000	1,000
--Total	1,304,900	1,310,000	1,342,500	1,436,500	1,445,200	1,441,600	1,449,300	1,453,600	1,474,100	1,442,200
• Annualized costs, $										
--Coating operation equipment	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500
--Mix room equipment	15,800	15,800	15,800	15,800	15,800	15,800	15,800	15,800	15,800	15,800
--Solvent storage tanks	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
--Coating operation control system	N/A	N/A	N/A	44,800	46,600	44,800	46,600	49,000	44,800	44,800
--Mix room control system	N/A	800	22,400	N/A	N/A	800	800	N/A	22,400	1,600
--Solvent storage tank control system*	N/A	200	200	N/A	200	200	200	200	200	200
--Credit/debit for solvent[e]	N/A	-2,200	400	3,300	3,400	1,100	1,200	3,700	3,700	3,700
--Total	1,728,900	1,727,700	1,751,900	1,777,000	1,779,100	1,775,800	1,777,700	1,781,800	1,800,000	1,779,200
•Total annualized operating costs,[f] ¢/m² (¢/ft²)										
--Coating operation	49.07 (4.56)	49.07 (4.56)	49.07 (4.56)	50.6 (4.69)	50.57 (4.70)	50.6 (4.69)	50.57 (4.70)	50.6 (4.69)	50.6 (4.69)	50.6 (4.69)
--Mix room	0.45 (0.04)	0.41 (0.04)	1.11 (0.10)	0.45 (0.04)	0.45 (0.04)	0.41 (0.04)	0.41 (0.04)	0.45 (0.04)	1.11 (0.10)	0.51 (0.05)
--Solvent storage tanks*	0.046 (0.004)	0.046 (0.005)	0.052 (0.005)	0.046 (0.004)	0.052 (0.005)	0.052 (0.005)	0.052 (0.005)	0.052 (0.005)	0.052 (0.005)	0.052 (0.005)
--Total	49.57 (4.604)	49.53 (4.605)	50.23 (4.665)	51.16 (4.734)	51.07 (4.745)	50.08 (4.735)	51.03 (4.745)	51.10 (4.735)	51.76 (4.795)	51.16 (4.745)
• Annualized control system costs, $										
--Coating operation	N/A	N/A	N/A	48,100	50,000	48,100	50,000	52,700	48,100	48,100
--Mix room	N/A	-1,400	22,800	N/A	N/A	-1,400	-1,400	N/A	22,800	2,000
--Solvent storage tanks*	N/A	200	200	N/A	200	200	200	200	200	200
--Total	N/A	-1,200	23,000	48,100	50,200	46,900	48,800	52,900	71,100	50,300
--Total cost per unit area,[f] ¢/m² (¢/ft²)	N/A	-0.034 (-0.003)	0.66 (0.06)	1.40 (0.13)	1.40 (0.13)	1.40 (0.13)	1.40 (0.13)	1.51 (0.14)	2.04 (0.19)	1.44 (0.13)

(continued)

TABLE 8-14. (continued)

Regulatory Alternatives:	X	XIA	XIB (Separate Fi-CA)[b]	XIB (Common Fi-CA)[c]	XII	XIII (Separate Fi-CA)[b]	XIII (Common Fi-CA)[c]	XIV
Cost item								
• Installed capital cost, $								
--Coating operation equipment[d]	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900	1,208,900
--Mix room equipment[d]	88,500	88,500	88,500	88,500	88,500	88,500	88,500	88,500
--Solvent storage tanks	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
--Coating operation control system	228,700	147,700	139,300	139,300	228,700	147,700	147,700	228,700
--Solvent storage tank control system*	N/A	4,100	36,600	4,700	4,100	36,600	4,700	36,600
	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
--Total	1,534,600	1,457,700	1,481,800	1,449,900	1,538,700	1,490,200	1,458,300	1,571,200
• Annualized costs, $								
--Coating operation equipment	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500	1,711,500
--Mix room equipment	15,800	15,800	15,800	15,800	15,800	15,800	15,800	15,800
--Solvent storage tanks	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
--Coating operation control system	67,500	49,000	46,600	46,600	67,500	49,000	49,000	67,500
--Mix room control system	N/A	800	22,400	1,600	800	22,400	1,600	22,400
--Solvent storage tank control system*	200	200	200	200	200	200	200	200
--Credit/debit for solvent[e]	N/A	1,500	3,800	3,800	-2,200	4,100	4,100	400
--Total	1,796,600	1,780,400	1,801,900	1,781,100	1,795,200	1,804,600	1,783,800	1,819,400
•Total annualized operating costs,[f] ¢/m^2 (¢/ft^2)								
--Coating operation	51.00	50.6	50.57	50.57	51.00	50.6	50.6	51.00
	(4.74)	(4.69)	(4.70)	(4.70)	(4.74)	(4.69)	(4.69)	(4.74)
--Mix room	0.45	0.41	1.11	0.51	0.41	1.11	0.51	1.11
	(0.04)	(0.04)	(0.10)	(0.05)	(0.04)	(0.10)	(0.05)	(0.10)
--Solvent storage tanks*	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
--Total	51.50	51.06	51.73	51.13	51.46	51.76	51.16	52.16
	(4.785)	(4.735)	(4.805)	(4.755)	(4.785)	(4.795)	(4.745)	(4.845)
• Annualized control system costs, $								
--Coating operation	67,500	52,700	50,000	50,000	67,500	52,700	52,700	67,500
--Mix room	N/A	-1,400	22,800	2,000	-1,400	22,800	2,000	22,800
--Solvent storage tanks*	200	N/A	200	200	200	200	200	200
--Total	67,700	51,500	73,000	52,200	66,300	75,700	54,900	90,500
--Total cost per unit area,[f] ¢/m^2 (¢/ft^2)	1.94	1.48	2.10	1.50	1.90	2.17	1.58	2.60
	(0.18)	(0.14)	(0.19)	(0.14)	(0.18)	(0.20)	(0.15)	(0.24)

N/A = Not applicable.

[a] Regulatory alternatives are defined in Table 6-10.

[b] A fixed-bed carbon adsorber (Fi-CA) controls the VOC emissions from the mix room only.

[c] VOC emissions from the mix room plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber (Fi-CA).

[d] Includes land and building costs.

[e] Area coated annually is 34.84 x10^5 m^2 (37.5 x10^6 ft^2).

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-10 in Appendix F for these revisions.

TABLE 8-15. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR TYPICAL MODEL LINES FOR EACH REGULATORY ALTERNATIVE[a,17]

Regulatory Alternatives:	I	II	III	IV	IV	IV	IV	V	V	IX
Cost item				(Fi-CA)[b]	(Flu-CA)[c]	(Nitrogen blend)[d]	(Nitrogen single)[e]	(Fi-CA)[b]	(Flu-CA)[c]	(Fi-CA)[b]
• Installed capital cost, $										
--Coating operation equipment[f]	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400
--Mix room equipment	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900
--Solvent storage tanks	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
--Coating operation control system	N/A	N/A	N/A	1,580,000	1,759,200	1,102,600	733,000	1,600,000	1,774,700	1,580,000
--Mix room control system	N/A	4,100	36,600	N/A	N/A	N/A	N/A	N/A	N/A	4,100
--Solvent storage tank control system*	N/A	1,000	1,000	N/A	N/A	N/A	N/A	1,000	1,000	1,000
--Total	3,067,500	3,072,600	3,105,100	4,647,500	4,826,700	4,170,100	3,800,500	4,667,500	4,843,200	4,652,600
• Annualized costs, $										
--Coating operation equipment	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,075,100	11,038,400	11,038,400	11,038,400	11,038,400
--Mix room equipment	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300
--Solvent storage tanks	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100
--Coating operation control system	N/A	N/A	N/A	414,400	467,900	279,200	188,700	420,600	471,100	414,400
--Mix room control system	N/A	800	26,200	N/A	N/A	N/A	N/A	N/A	N/A	800
--Solvent storage tank control system*	N/A	200	200	N/A	N/A	N/A	N/A	200	200	200
--Credit/debit for solvent[g]	N/A	-21,700	3,900	-362,400	-362,400	-362,400	-378,200	-379,900	-379,900	-384,100
--Total	11,125,800	11,105,100	11,156,100	11,177,800	11,231,300	11,042,600	10,976,300	11,166,500	11,217,200	11,157,100
•Total annualized operating costs,[h] ¢/m^2 (¢/ft^2)										
--Coating operation	31.68 (2.94)	31.68 (2.94)	31.68 (2.94)	31.83 (2.96)	31.99 (2.97)	31.4 (2.90)	31.2 (2.90)	31.84 (2.95)	31.94 (2.97)	31.83 (2.93)
--Mix room	0.23 (0.02)	0.23 (0.02)	0.32 (0.03)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.17 (0.02)
--Solvent storage tanks*	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)
--Total	31.93 (2.962)	31.93 (2.962)	32.02 (2.972)	32.08 (2.982)	32.24 (2.992)	31.64 (2.922)	31.45 (2.922)	32.05 (2.972)	31.19 (2.992)	32.02 (2.952)
• Annualized control system costs, $										
--Coating operation	N/A	N/A	N/A	52,000	105,500	-83,200	-189,500	40,800	81,300	52,000
--Mix room	N/A	-20,800	30,100	N/A	N/A	N/A	N/A	N/A	N/A	-20,800
--Solvent storage tanks*	N/A	100	100	N/A	N/A	N/A	N/A	100	100	100
--Total	N/A	-20,700	30,200	52,000	105,500	-83,200	-189,500	40,900	81,400	31,300
--Total cost per unit area,[h] ¢/m^2 (¢/ft^2)	N/A	-0.059 (-0.006)	0.087 (0.008)	0.15 (0.014)	0.30 (0.028)	-0.24 (-0.022)	-0.54 (-0.051)	0.12 (0.011)	0.23 (0.022)	0.090 (0.008)

(continued)

TABLE 8-15. INSTALLED CAPITAL AND ANNUALIZED COSTS, AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED, FOR TYPICAL MODEL LINES FOR EACH REGULATORY ALTERNATIVE[a,17]

Regulatory Alternatives:	I	II	III	IV	IV	IV	IV	V	V	IX
Cost item				(Fi-CA)[b]	(Flu-CA)[c]	(Nitrogen blend)[d]	(Nitrogen single)[e]	(Fi-CA)[b]	(Flu-CA)[c]	(Fi-CA)[b]
• Installed capital cost, $										
--Coating operation equipment[f]	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400
--Mix room equipment[f]	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900
--Solvent storage tanks	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
--Coating operation control system	N/A	N/A	N/A	1,580,000	1,759,200	1,102,600	733,000	1,600,000	1,774,700	1,580,000
--Mix room control system	N/A	4,100	36,600	N/A	N/A	N/A	N/A	N/A	N/A	4,100
--Solvent storage tank control system*	N/A	1,000	1,000	N/A	N/A	N/A	N/A	1,000	1,000	1,000
--Total	3,067,500	3,072,600	3,105,100	4,647,500	4,826,700	4,170,100	3,800,500	4,667,500	4,843,200	4,652,600
• Annualized costs, $										
--Coating operation equipment	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,075,100	11,038,400	11,038,400	11,038,400	11,038,400
--Mix room equipment	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300
--Solvent storage tanks	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100
--Coating operation control system	N/A	N/A	N/A	414,400	467,900	279,200	188,700	420,600	471,100	414,400
--Mix room control system	N/A	800	26,200	N/A	N/A	N/A	N/A	N/A	N/A	800
--Solvent storage tank control system*	N/A	200	200	N/A	N/A	N/A	N/A	200	200	200
--Credit/debit for solvent[g]	N/A	-21,700	3,900	-362,400	-362,400	-362,400	-378,200	-379,900	-379,900	-384,100
--Total	11,125,800	11,105,100	11,156,100	11,177,800	11,231,300	11,042,600	10,976,300	11,166,500	11,217,200	11,157,100
•Total annualized operating costs,[h] ¢/m^2 (¢/ft^2)										
--Coating operation	31.68 (2.94)	31.68 (2.94)	31.68 (2.94)	31.83 (2.96)	31.99 (2.97)	31.4 (2.90)	31.2 (2.90)	31.84 (2.95)	31.94 (2.97)	31.83 (2.93)
--Mix room	0.23 (0.02)	0.23 (0.02)	0.32 (0.03)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.23 (0.02)	0.17 (0.02)
--Solvent storage tanks*	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)
--Total	31.93 (2.962)	31.93 (2.962)	32.02 (2.972)	32.08 (2.982)	32.24 (2.992)	31.64 (2.922)	31.45 (2.922)	32.05 (2.972)	31.19 (2.992)	32.02 (2.952)
• Annualized control system costs, $										
--Coating operation	N/A	N/A	N/A	52,000	105,500	-83,200	-189,500	40,800	81,300	52,000
--Mix room	N/A	-20,800	30,100	N/A	N/A	N/A	N/A	N/A	N/A	-20,800
--Solvent storage tanks*	N/A	100	100	N/A	N/A	N/A	N/A	100	100	100
--Total	N/A	-20,700	30,200	52,000	105,500	-83,200	-189,500	40,900	81,400	31,300
--Total cost per unit area,[h] ¢/m^2 (¢/ft^2)	N/A	-0.059 (-0.006)	0.087 (0.008)	0.15 (0.014)	0.30 (0.028)	-0.24 (-0.022)	-0.54 (-0.051)	0.12 (0.011)	0.23 (0.022)	0.090 (0.008)

(continued)

TABLE 8-15. (continued)

Cost item / Regulatory Alternatives:	IX (Fl-CA Flu-CA)[j]	IX (Common Fl-CA)[k]	IX (Nitrogen blend)[d]	IX (Nitrogen single)[e]	X	XIA (Fl-CA)[b]	XIA (Flu-CA)[c]	XIA (Nitrogen blend)[d]	XIA (Nitrogen single)[e]	XIB (Separate) (Fl-CA)[i]
• Installed capital cost, $										
--Coating operation equipment[f]	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400
--Mix room equipment	394,900	394,900	394,900	394,900	394,900	394,900	394,900	3[illegible]00	394,900	394,900
--Solvent storage tanks	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
--Coating operation control system	1,759,200	1,580,000	1,102,600	733,000	300,300	1,607,200	1,784,000	1,117,300	747,700	1,600,000
--Mix room control system	36,600	4,700	36,600	36,600	N/A	4,100	4,100	4,100	4,100	36,600
--Solvent storage tank control system*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
--Total	4,864,300	4,653,200	4,207,700	3,838,100	3,368,800	4,679,800	4,856,600	4,189,900	3,820,300	4,705,100
• Annualized costs, $										
--Coating operation equipment	11,038,400	11,038,400	11,038,400	11,075,100	11,038,400	11,038,400	11,038,400	11,038,400	11,075,100	11,038,400
--Mix room equipment	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300
--Solvent storage tanks	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100
--Coating operation control system	467,900	414,400	279,200	188,700	153,500	425,000	473,000	282,200	191,600	420,600
--Mix room control system	26,200	6,500	26,200	26,200	N/A	800	800	800	800	26,200
--Solvent storage tank control system*	200	200	200	200	200	200	200	200	200	200
--Credit/debit for solvent[g]	-358,600	-408,700	-358,600	-374,400	-100	-402,300	-402,300	-402,300	-420,000	-376,000
--Total	11,620,100	11,138,200	11,072,800	11,003,200	11,279,400	11,149,500	11,197,500	11,006,700	10,935,100	11,196,800
•Total annualized operating costs,[h] $/m^2 ($/ft^2)										
--Coating operation	31.99	31.83	31.4	31.2	32.12	31.74	31.94	31.3	31.1	31.80
	(2.97)	(2.96)	(2.90)	(2.90)	(2.98)	(2.95)	(2.95)	(2.90)	(2.90)	(2.95)
--Mix room	0.32	0.12	0.32	0.32	0.23	0.17	0.17	0.17	0.17	0.32
	(0.03)	(0.01)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
--Solvent storage tanks*	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
--Total	32.33	31.97	31.74	31.54	32.37	31.93	32.13	31.49	31.29	32.14
	(3.002)	(2.972)	(2.932)	(2.932)	(3.002)	(2.972)	(2.972)	(2.922)	(2.922)	(2.982)
• Annualized control system costs, $										
--Coating operation	105,500	52,000	-83,200	-189,500	153,500	18,900	66,900	-123,900	-232,200	40,800
--Mix room	30,100	-39,700	30,100	30,100	N/A	-20,800	-20,800	-20,800	-20,800	30,100
--Solvent storage tanks*	100	100	100	100	100	100	100	100	100	100
--Total	135,700	12,400	-53,000	-159,300	153,600	-1,800	46,200	-144,600	-252,900	71,000
--Total cost per unit area,[h] $/m^2 ($/ft^2)	0.39	0.04	-0.15	-0.46	0.44	-0.01	0.13	-0.42	-0.73	0.20
	(0.036)	(0.003)	(-0.014)	(-0.042)	(0.041)	(-0.001)	(0.01)	(-0.039)	(-0.067)	(0.019)

(continued)

TABLE 8-15. (continued)

Cost item / Regulatory Alternatives:[b]	XIB (Fi-CA Flu-CA)[j]	XIB (Common Fi-CA)[k]	XII	XIII (Separate (Fi-CA)[i]	XIII (Fi-CA Flu-CA)[j]	XIII (Common Fi-CA)	XIII (Nitrogen blend)[d]	XIII (Nitrogen single)[e]	XIV
• Installed capital cost, $									
--Coating operation equipment[f]	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400	2,644,400
--Mix room equipment[f]	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900	394,900
--Solvent storage tanks	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
--Coating operation control system	1,774,700	1,600,000	300,300	1,607,200	1,784,000	1,607,200	1,117,300	747,700	300,300
--Mix room control system	36,600	4,700	4,100	36,600	36,600	4,700	36,600	36,600	36,600
--Solvent storage tank control system*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
--Total	4,879,800	4,673,200	3,372,900	4,712,300	4,889,100	4,680,400	4,222,400	3,852,800	3,405,400
• Annualized costs, $									
--Coating operation equipment	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,038,400	11,075,100	11,038,400
--Mix room equipment	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300	81,300
--Solvent storage tanks	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100
--Coating operation control system	471,100	420,600	153,500	425,000	473,000	425,000	282,200	191,600	153,500
--Mix room control system	26,200	6,500	800	26,200	26,200	6,500	26,200	26,200	26,200
--Solvent storage tank control system*	200	200	200	200	200	200	200	200	200
--Credit/debit for solvent[g]	-376,000	-426,100	-21,700	-402,000	-402,000	-452,400	-402,000	-420,000	3,800
--Total	11,247,300	11,127,000	11,258,600	11,175,200	11,223,200	11,105,100	11,032,400	10,960,500	11,309,500
•Total annualized operating costs,[h] ¢/m^2 (¢/ft^2)									
--Coating operation	31.94 (2.96)	31.80 (2.95)	32.12 (2.98)	31.74 (2.95)	31.88 (2.96)	31.94 (2.95)	31.3 (2.90)	31.1 (2.90)	32.12 (2.98)
--Mix room	0.32 (0.03)	0.12 (0.01)	0.17 (0.02)	0.32 (0.03)	0.32 (0.03)	0.12 (0.01)	0.32 (0.03)	0.32 (0.03)	0.32 (0.03)
--Solvent storage tanks*	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)	0.02 (0.002)
--Total	32.28 (2.992)	31.94 (2.962)	32.31 (3.002)	32.08 (2.982)	32.22 (2.992)	32.08 (2.962)	31.64 (2.932)	31.44 (2.932)	32.46 (3.012)
• Annualized control system costs, $									
--Coating operation	81,300	40,800	153,500	18,900	66,900	18,900	-123,900	-232,200	153,500
--Mix room	30,100	-39,700	-20,800	30,100	30,100	-39,700	30,100	30,100	30,100
--Solvent storage tanks*	100	100	100	100	100	100	100	100	100
--Total	111,500	1,200	132,800	49,100	97,100	-20,700	-93,700	-202,000	183,700
--Total cost per unit area,[h] ¢/m^2 (¢/ft^2)	0.32 (0.030)	0.003 (0.0003)	0.38 (0.035)	0.14 (0.013)	0.28 (0.026)	-0.06 (-0.051)	-0.27 (0.025)	-0.58 (0.054)	0.53 (0.049)

N/A = Not applicable.

[a] Regulatory alternatives are defined in Table 6-10.

[b] A fixed-bed carbon adsorber (Fi-CA) controls emissions from the coating operation.

[c] A fluidized-bed carbon adsorber (Flu-CA) controls emissions from the coating operation.

[d] Nitrogen condenser recovering a blend of solvents.

[e] Nitrogen condenser recovering cyclohexanone only.

[f] Includes land and building costs.

[g] Negative values are credits for reuse of solvents.

[h] Area coated annually is 34.84 x10^6 m^2 (375 x10^6 ft^2).

[i] Emissions from the mix room and coating line are controlled by separate fixed-bed carbon adsorbers.

[j] A fixed-bed carbon adsorber controls emissions from the mix room, a fluidized-bed carbon adsorber controls emissions from the coating operation.

[k] VOC emissions from the mix room plus VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-6 through F-10 in Appendix F for the revisions.

TABLE 8-16. AVERAGE COST EFFECTIVENESS OF CONTROL OPTIONS WITH RESPECT TO UNCONTROLLED BASELINE (I) FOR MODEL SOLVENT STORAGE TANKS*

Parameter	Control options		
	Conservation vents	Separate disposable carbon adsorbers[a]	Common fixed-bed carbon adsorbers[b]
1. Research			
• Total annualized control system cost, $/yr[c]	340	7,900	6,400
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.011 (0.011)	0.029 (0.029)	0.029 (0.029)
• Average cost effectiveness, $/Mg ($/ton)	30,900 (30,900)	272,400 (272,400)	220,700 (220,700)
2. Small			
• Total annualized control system cost, $/yr[c]	200	4,800	5,100
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.018 (0.018)	0.048 (0.048)	0.048 (0.048)
• Average cost effectiveness, $/Mg ($/ton)	11,100 (11,100)	100,000 (100,000)	106,200 (106,200)
3. Typical			
• Total annualized control system cost, $/yr[c]	100	5,800	4,800
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.14 (0.15)	0.37 (0.41)	0.37 (0.41)
• Average cost effectiveness, $/Mg ($/ton)	700 (670)	15,700 (14,100)	13,000 (11,700)

[a] A disposable-canister carbon adsorber controls the VOC emissions from the storage tanks only.

[b] VOC emissions from the storage tanks plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

[c] The costs for the common fixed-bed carbon adsorbers are for the incremental control device cost above that required for control of the coating operation alone.

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-11 in Appendix F for these revisions.

TABLE 8-17. INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR MODEL SOLVENT STORAGE TANKS*

Parameter	Regulatory alternatives and control device		
	CV/ Unc.[a]	S-CA/CV[b]	C-CA/CV[c]
1. Research			
• Incremental total annualized control system cost, \$/yr	340	7,560	6,060[d]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.011 (0.011)	0.016 (0.018)	0.016 (0.018)
• Incremental cost effectiveness, \$/Mg (\$/ton)	30,900 (30,900)	472,500 (420,000)	378,800 (336,700)
2. Small			
• Incremental total annualized control system cost, \$/yr	200	4,600	4,900[d]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.016 (0.018)	0.027 (0.030)	0.027 (0.030)
• Incremental cost effectiveness, \$/Mg (\$/ton)	12,500 (11,100)	170,400 (153,300)	181,500 (163,300)
3. Typical			
• Incremental total annualized control system cost, \$/yr	100	5,700	4,700[d]

(continued)

TABLE 8-17. (continued)

Parameter	Regulatory alternatives and control device		
	CV/ Unc.[a]	S-CA/CV[b]	C-CA/CV[c]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.14 (0.15)	0.23 (0.26)	0.23 (0.26)
• Incremental cost effectiveness, $/Mg ($/ton)	700 (670)	24,800 (21,900)	20,400 (18,100)

[a] The incremental change for model solvent storage tanks controlled by conservation vents (CV) compared to uncontrolled model solvent storage tanks.

[b] The incremental change for model solvent storage tanks controlled by a disposable-canister carbon adsorber (S-CA) compared to model storage tanks controlled by conservation vents (CV).

[c] The incremental change for model solvent storage tanks controlled by a fixed-bed carbon adsorber also controlling emissions from the coating operation (C-CA) compared to model storage tanks controlled by conservation vents (CV).

[d] The costs for common fixed-bed carbon adsorbers are for the incremental control device cost above that required for control of the coating operation alone.

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-12 in Appendix F for these revisions.

TABLE 8-18. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES WITH RESPECT TO UNCONTROLLED BASELINE (I) FOR MODEL MIX ROOMS

Parameter	Regulatory alternatives		
	II (Covers)	III (Separate carbon adsorbers)[a]	IX (Common carbon adsorbers)[b]
1. Research			
• Total annualized control system cost, $/yr	-270	12,200	1,100
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.91 (1)	2.7 (3)	2.7 (3)
• Average cost effectiveness, $/Mg ($/ton)	-300 (-270)	4,500 (4,100)	400 (400)
2. Small			
• Total annualized control system cost, $/yr	-1,400	22,800	2,000[c]
• Total annual VOC emission reduction, Mg/yr (tons/yr)	2.7 (3)	7.3 (8)	7.3 (8)
• Average cost effectiveness, $/Mg ($/ton)	-500 (-500)	3,100 (2,900)	300 (250)
3. Typical			
• Total annualized control system cost, $/yr[d]	-20,800	30,100	-39,700[c]
• Total annual VOC emission reduction, Mg/yr (tons/yr)	28 (31)	67 (74)	67 (74)
• Average cost effectiveness, $/Mg ($/ton)	-740 (-670)	500 (400)	-600 (-500)

[a] A fixed-bed carbon adsorber controls the VOC emissions from the mix room only.

[b] VOC emissions from the mix room plus the VOC emissions from the coating operation controlled by the same fixed-bed carbon adsorber for these regulatory alternatives.

[c] The costs are for the incremental control device cost above that required for control of the coating operation alone.

[d] A negative value indicates a net credit due to the value of the recovered solvents.

TABLE 8-19. INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR MODEL MIX ROOM

Parameter	Regulatory alternatives and control device		
	II (CV)/I (Unc.)[a]	III (S-CA)/ II (CV)[b]	IX (C-CA)/ II (CV)[c]
1. Research			
• Incremental total annualized control system cost, $/yr	-270	12,470	1,370
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.91 (1)	1.8 (2)	1.8 (2)
• Incremental cost effectiveness, $/Mg ($/ton)	-300 (-270)	6,900 (6,200)	760 (680)
2. Small			
• Incremental total annualized control system cost, $/yr	-1,360	24,200	3,360[d]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	2.7 (3)	4.6 (5)	4.6 (5)
• Incremental cost effectiveness, $/Mg ($/ton)	-500 (-450)	5,300 (4,800)	730 (670)

(continued)

TABLE 8-19. (continued)

Parameter	Regulatory alternatives and control device		
	II (CV)/I (Unc.)[a]	III (S-CA)/ II (CV)[b]	IX (C-CA)/ II (CV)[c]
3. Typical			
• Incremental total annualized control system cost, \$/yr	-20,800	50,900	-18,900
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	28 (31)	39 (43)	39 (43)
• Incremental cost effectiveness, \$/Mg (\$/ton)	-740 (-670)	1,300 (1,200)	-490 (440)

[a] The incremental change for model mix rooms controlled by conservation vent (CV) compared to uncontrolled model mix rooms (Unc.).

[b] The incremental change for model mix rooms controlled by a separate carbon adsorber (S-CA) compared to model mix rooms controlled by conservation vent (CV).

[c] The incremental change for model mix rooms controlled by a fixed-bed carbon adsorber also controlling emissions from the coating operation (C-CA) compared to model mix rooms controlled by conservation vent (CV).

[d] The costs are for the incremental control device cost above that is required for control of the coating operation alone.

TABLE 8-20. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES WITH RESPECT TO UNCONTROLLED BASELINE (I) FOR MODEL COATING OPERATIONS

Parameter	Control device and regulatory alternative										
	Fixed-bed carbon adsorber			Fluidized-bed carbon adsorber[a]			Incinerator	Nitrogen condenser[b]			
	IV	V	VIII	IV	V	VIII	X	IV (single)[c]	IV (blend)[d]	VIII (single)	VIII (blend)
1. Research											
• Total annualized control system cost, $/yr	33,800	35,500	37,400				53,700				
• Total annual VOC emission reduction, Mg/yr (tons/yr)	19 (21)	20 (22)	21 (23)				22 (24)				
• Average cost effectiveness, $/Mg ($/ton)	1,800 (1,600)	1,800 (1,600)	1,800 (1,600)				2,400 (2,200)				
2. Small											
• Total annualized control system cost, $/yr	48,100	50,000	52,700				67,500				
• Total annual VOC emission reduction, tons/yr	56 (62)	59 (65)	63 (70)				64 (71)				
• Average cost effectiveness, $/Mg ($/ton)	860 (780)	850 (770)	840 (750)				1,100 (950)				
3. Typical											
• Total annualized control system cost, $/yr[e]	52,000	40,800	18,900	105,500	91,300	66,900	153,500	-189,500	-83,200	-232,200	-123,900
• Total annual VOC emissions reduction, Mg/yr (tons/yr)	527 (581)	553 (609)	590 (651)	527 (581)	553 (609)	590 (651)	603 (665)	527 (581)	527 (581)	590 (651)	590 (651)
• Average cost effectiveness, $/Mg ($/ton)[e]	100 (90)	70 (70)	30 (30)	200 (180)	160 (150)	110 (100)	250 (230)	-360 (-330)	-160 (-140)	-390 (-360)	210 (-190)

[a] Fluidized-bed carbon adsorbers cannot be designed for the research and small model line sizes.

[b] Nitrogen condensers cannot be designed for coating operations the size of the research and small lines and cannot be used with Regulatory Alternative III (partial enclosure) because of the requirement for a closed N_2 recirculation system.

[c] Single = cyclohexanone is the only solvent used in the coating mix.

[d] Blend = a solvent blend of 40% THF, 40% toluene, and 20% cyclohexanone used in the coating mix.

[e] A negative value means an overall net gain due to the value of the recovered solvents.

TABLE 8-21. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES WITH RESPECT TO CONTROLLED BASELINE (IV) FOR MODEL COATING OPERATIONS[10]

	Control device and regulatory alternative						
	Fixed-bed carbon adsorber		Fluidized-bed carbon adsorber[a]		Incinerator[b]	Nitrogen condensers[c]	
Parameter	V	VIII	V	VIII	X	VIII (single)[d]	VIII (blend)[e]
1. Research							
• Total annualized control system cost, $/yr	1,700	3,600			19,900		
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.9 (1)	1.8 (2)			2.7 (3)		
• Average cost effectiveness, $/Mg ($/ton)	1,900 (1,700)	2,000 (1,800)			7,400 (6,600)		
2. Small							
• Total annualized control system cost, $/yr	1,900	4,600			19,400		
• Total annual VOC emission reduction, Mg/yr (tons/yr)	2.7 (3)	7.3 (8)			8.2 (9)		
• Average cost effectiveness, $/Mg ($/ton)	700 (630)	630 (580)			2,400 (2,200)		
3. Typical							
• Total annualized control system cost, $/yr[f]	1,200	3,100	-14,200	-38,600	101,500	-42,700	-40,700
• Total annual VOC emissions reduction, Mg/yr (tons/yr)	25 (28)	63 (70)	25 (28)	63 (70)	76 (84)	63 (70)	63 (70)
• Average cost effectiveness, $/Mg ($/ton)[f]	-450 (-400)	-520 (-470)	-560 (-510)	-610 (-550)	1,300 (1,200)	-670 (-610)	-640 (-580)

[a] Fluidized-bed carbon adsorbers cannot be designed for the research and small lines.

[b] For incinerator, controlled baseline is Regulatory Alternative IV for fixed-bed carbon adsorber.

[c] Nitrogen condensers cannot be designed for coating operations the size of the research and small lines and cannot be used with Regulatory Alternative V (partial enclosure) because of the requirement for a closed N_2 recirculation system. No cost estimates for the air refrigeration system have been received from the vendor.

[d] Single = cyclohexanone is the only solvent used in the coating mix.

[e] Blend = a solvent mix of 40% THF, 40% toluene, and 20% cyclohexanone used in the coating mix.

[f] A negative value indicates a net credit due to the value of the recovered solvents.

TABLE 8-22. INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR MODEL COATING OPERATIONS

Parameter	Control device and regulatory alternative										
	Fixed-bed carbon adsorber			Fluidized-bed carbon adsorber[a]			Incinerator	Nitrogen condenser[b]			
	IV/I	V/IV	VIII/V	IV/I	V/IV	VIII/V	X/VIII	IV/I (single)[c]	VIII/IV (single)[c]	IV/I (blend)[d]	VIII/IV (blend)[d]
1. **Research**											
• Incremental annualized control system cost, $/yr	33,800	1,700	1,900				16,300				
• Incremental annual VOC emission reduction, Mg/yr (tons/yr)	19 (21)	0.9 (1)	0.9 (1)				0.9 (1)				
• Incremental cost effectiveness, $/Mg ($/ton)	1,800 (1,600)	1,900 (1,700)	2,100 (1,900)				18,100 (16,300)				
2. **Small**											
• Incremental annualized control system cost, $/yr	48,100	1,900	2,700				14,800				
• Incremental annual VOC emission reduction, Mg/yr (tons/yr)	56 (62)	2.7 (3)	4.5 (5)				0.9 (1)				
• Incremental cost effectiveness, $/Mg ($/ton)	860 (780)	700 (630)	600 (540)				16,400 (14,800)				
3. **Typical**											
• Incremental annualized control system cost, $/yr[e]	52,000	-11,200	-21,900	52,600	-14,300	-20,200	130,800	-189,500	-38,100	-83,200	-36,500
• Incremental annual VOC emission reduction, Mg/yr (tons/yr)	527 (581)	25 (28)	38 (42)	527 (581)	25 (28)	38 (42)	13 (14)	527 (581)	63 (70)	527 (581)	63 (70)
• Incremental cost effectiveness, $/Mg ($/ton)[e]	100 (90)	-450 (-400)	-580 (-520)	100 (90)	-570 (-510)	-530 (-480)	10,100 (9,300)	-380 (-330)	-600 (-540)	-160 (-140)	-580 (-520)

[a] Fluidized-bed carbon adsorbers cannot be designed for the research and small line sizes.

[b] Nitrogen condenser cannot be designed for coating operations the size of the research and small lines and cannot be used with Regulatory Alternative V (partial enclosure) because of the requirement for a closed N_2 recirculation system.

[c] Single = cyclohexanone is the only solvent used in the coating mix.

[d] Blend = a solvent mix of 40% THF, 40% toluene, and 20% cyclohexanone used in the coating mix.

[e] Negative values indicate a net credit due to the value of recovered solvents.

TABLE 8-23. AVERAGE AND INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR RESEARCH MODEL LINES

Reg. alt.	Storage tanks[a,*] Control	Mix room[b] Control	Coating operation[c] Capture, control	Annualized control device cost, $	Emission reduction, Mg/yr (ton/yr)	Cost effectiveness, $/Mg ($/ton)		
						Average[d]		
						Baseline (I)	Baseline (IV)	Incremental
I	None	None	None, None	0	0 (0)	0 (0)	N/A	N/A
II	CV	Covers	None, None	0	0.91 (1)	0 (0)	N/A	0 (0)
III	CV	Fi-CA	None, None	12,500	2.72 (3)	4,600 (4,200)	N/A	6,800 (6,200)
IV	None	None	None, Fi-CA	33,800	19.1 (21)	1,800 (1,600)	N/A	1,300 (1,200)
V	CV	None	PE, Fi-CA	35,800	20.0 (22)	1,800 (1,600)	2,200 (2,000)	2,200 (2,000)
VI	CV	Covers	None, Fi-CA	33,800	20.0 (22)	1,700 (1,500)	0 (0)	0 (0)
VII	CV	Covers	PE, Fi-CA	35,500	20.9 (23)	1,700 (1,500)	940 (850)	1,900 (1,700)
VIII	CV	None	TE, Fi-CA	37,700	20.9 (23)	1,800 (1,600)	2,200 (2,000)	4,300 (3,900)
IX	CV	Fi-CA	None, Fi-CA	46,300	21.8 (24)	2,100 (1,900)	4,600 (4,200)	9,500 (8,600)
IX	CV	Fi-CA	None, Common	35,100	21.8 (24)	1,600 (1,500)	470 (430)	-2,900 (-2,600)
X	CV	None	TE, Inc.	54,000	21.8 (24)	2,500 (2,300)	7,400 (6,700)	18,000 (16,300)
XIA	CV	Covers	TE, Fi-CA	37,400	21.8 (24)	1,700 (1,600)	1,300 (1,200)	-330 (-300)
XIB	CV	Fi-CA	PE, Fi-CA	48,000	22.7 (25)	2,100 (1,900)	4,000 (3,600)	11,700 (10,600)
XIB	CV	Fi-CA	PE, Common	36,800	22.7 (25)	1,600 (1,500)	830 (750)	660 (-600)
XII	CV	Covers	TE, Inc.	53,700	22.7 (25)	2,400 (2,200)	5,500 (5,000)	18,000 (16,300)
XIII	CV	Fi-CA	TE, Fi-CA	49,900	23.6 (26)	2,100 (1,900)	3,500 (3,200)	-4,200 (-3,800)
XIII	CV	Fi-CA	TE, Common	38,700	23.6 (26)	1,600 (1,500)	1,100 (1,000)	-16,500 (-15,000)
XIV	CV	Fi-CA	TE, Inc.	66,200	24.5 (27)	2,700 (2,400)	6,000 (5,400)	30,300 (27,500)[e]

N/A = Not applicable.

[a] Storage tank emissions controlled by conservation vents (CV).

[b] Mix room emissions controlled by covers with conservation vents or fixed-bed carbon adsorber (Fi-CA).

[c] Coating operation emissions captured by partial enclosure (PE) or total enclosure (TE). Coating operation emissions controlled by separate fixed-bed carbon adsorber (Fi-CA), incinerator (Inc.), or fixed-bed carbon adsorber controlling emissions from both the mix room and coating operation (Common).

[d] Average cost effectiveness compared to uncontrolled baseline (I) and controlled baseline (IV).

[e] Incremental cost is determined from lowest annualized control device cost for regulatory alternative with equivalent emission reduction.

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-6 through F-10 in Appendix F for these revisions.

TABLE 8-24. AVERAGE AND INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR SMALL MODEL LINES

Reg. alt.	Storage tanks[a],*	Mix room[b]	Coating operation[c]	Annualized control device cost, $	Emission reduction, Mg/yr (ton/yr)	Cost effectiveness, $/Mg ($/ton)		
						Average[d]		
	Control	Control	Capture, control			Baseline (I)	Baseline (IV)	Incremental
I	None	None	None, None	0	0 (0)	0 (0)	N/A	N/A
II	CV	Covers	None, None	-1,200	2.7 (3)	-440 (-400)	N/A	-440 (-400)
III	CV	Fi-CA	None, None	23,000	7.3 (8)	3,200 (2,900)	N/A	770 (700)
IV	None	None	None, Fi-CA	48,100	56 (62)	860 (780)	N/A	-510 (-460)
V	CV	None	PE, Fi-CA	50,200	59 (65)	850 (770)	710 (700)	770 (700)
VI	CV	Covers	None, Fi-CA	46,900	59 (65)	800 (720)	-440 (-400)	-440 (-400)
VII	CV	Covers	PE, Fi-CA	48,800	62 (68)	790 (720)	130 (120)	690 (630)
VIII	CV	None	TE, Fi-CA	52,900	63 (69)	850 (770)	750 (680)	4,500 (4,100)
IX	CV	Fi-CA	None, Fi-CA	71,100	64 (70)	1,100 (1,000)	3,200 (2,900)	20,300 (18,400)
IX	CV	Fi-CA	None, Common	50,300	64 (70)	790 (720)	300 (280)	-2,900 (-2,600)
X	CV	None	TE, Inc.	67,700	64 (71)	1,050 (950)	2,400 (2,200)	19,200 (17,400)[e]
XIA	CV	CV	TE, Fi-CA	51,500	65 (72)	780 (710)	370 (340)	-17,900 (-16,200)
XIB	CV	Fi-CA	PE, Fi-CA	73,000	66 (73)	1,100 (1,000)	2,500 (2,300)	23,700 (21,500)
XIB	CV	Fi-CA	PE, Common	52,200	66 (73)	790 (720)	400 (370)	770 (700)
XII	CV	Covers	TE, Inc.	66,300	67 (74)	990 (900)	1,700 (1,500)	-15,500 (-14,100)[e]
XIII	CV	Fi-CA	TE, Fi-CA	75,700	70 (77)	1,100 (980)	2,000 (1,900)	3,400 (3,100)
XIII	CV	Fi-CA	TE, Common	54,900	70 (77)	780 (710)	500 (450)	-4,200 (-3,800)
XIV	CV	Fi-CA	TE, Inc.	90,500	72 (79)	1,200 (1,100)	2,700 (2,500)	19,600 (17,800)

N/A = Not applicable.

[a] Storage tank emissions controlled by conservation vent (CV).

[b] Mix room emissions controlled by covers with conservation vent or fixed-bed carbon adsorber (Fi-CA).

[c] Coating operation emissions captured by partial enclosure (PE) or total enclosure (TE). Coating operation emissions controlled by separate fixed-bed carbon adsorber (Fi-CA), incinerator (Inc.), or fixed-bed carbon adsorber controlling emissions from both the mix room and coating operation (Common).

[d] Average cost effectiveness compared to uncontrolled baseline (I) and controlled baseline (IV).

[e] Incremental cost is determined from lowest annualized control device cost for regulatory alternatives with equivalent emission reduction.

*The control options and costs for solvent storage tanks have been revised. See Tables F-2 and F-6 through F-10 in Appendix F for these revisions.

TABLE 8-25. AVERAGE AND INCREMENTAL COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR TYPICAL MODEL LINES

Reg. alt.	Storage tanks[a,e] Control	Mix room[b] Control	Coating operation[c] Capture, control	Annualized control device cost, $	Emission reduction, Mg/yr (ton/yr)	Cost effectiveness, $/Mg ($/ton) Average[d] Baseline (I)	Baseline (IV)	Incremental
I	None	None	None, None	0	0 (0)	N/A	N/A	N/A
II	CV	Covers	None, None	-20,700	28 (31)	-740 (-670)	N/A	-740 (-670)
III	CV	Fi-CA	None, None	30,200	20 (74)	450 (410)	N/A	1,300 (1,200)
IV	None	None	None, Fi-CA	52,000	527 (581)	100 (90)	N/A	40 (40)
IV	None	None	None, Flu-CA	105,500	527 (581)	200 (180)	N/A	160 (150)
IV	None	None	None, Nitrogen[f]	-83,200	527 (581)	-150 (-140)	N/A	-240 (-220)
IV	None	None	None, Nitrogen[g]	-189,500	527 (581)	-360 (-330)	N/A	-470 (-430)
V	CV	None	PE, Fi-CA	40,900	552 (609)	80 (70)	-440 (-400)	-440 (-400)
V	CV	None	PE, Flu-CA	81,400	552 (609)	140 (130)	-950 (-860)	-950 (-860)
VI	CV	Covers	None, Fi-CA	31,300	555 (612)	60 (50)	-740 (-670)	-3,500 (-3,200)
VI	CV	Covers	None, Flu-CA	84,800	555 (612)	150 (140)	-740 (-670)	1,200 (1,100)
VI	CV	Covers	None, Nitrogen[f]	-103,900	555 (612)	-190 (-170)	-740 (-670)	-68,100 (-61,800)
VI	CV	Covers	None, Nitrogen[g]	-210,200	555 (612)	-370 (-340)	-740 (-670)	-107,200 (-97,200)
VII	CV	Covers	PE, Fi-CA	20,100	580 (640)	30 (30)	-600 (-540)	-440 (-400)
VII	CV	Covers	PE, Flu-CA	60,600	580 (640)	100 (90)	-840 (-760)	-950 (-860)
VIII	CV	None	TE, Fi-CA	19,000	584 (644)	30 (30)	-570 (-520)	-310 (-280)
VIII	CV	None	TE, Flu-CA	67,000	584 (644)	110 (100)	-670 (-610)	1,800 (1,600)
VIII	CV	None	TE, Nitrogen[f]	-123,800	584 (644)	-210 (-190)	-700 (-640)	-40,000 (-36,000)
VIII	CV	None	TE, Nitrogen[g]	-232,100	584 (644)	-400 (-360)	-750 (-680)	-69,600 (-63,100)
IX	CV	Fi-CA	None, Fi-CA	82,200	594 (655)	130 (120)	450 (410)	6,300 (5,700)
IX	CV	Fi-CA	None, Flu-CA	135,700	594 (655)	230 (210)	450 (410)	6,800 (6,200)
IX	CV	Fi-CA	None, Common	12,400	594 (655)	20 (20)	-590 (-540)	-660 (-600)
IX	CV	Fi-CA	None, Nitrogen[f]	-53,000	594 (655)	-90 (-80)	450 (410)	7,100 (6,400)
IX	CV	Fi-CA	None, Nitrogen[g]	-159,300	594 (655)	-260 (-240)	450 (410)	7,300 (6,600)
X	CV	None	TE, Inc.	153,600	603 (665)	250 (230)	1,300 (1,200)	2,800 (7,100)
XIA	CV	Covers	TE, Fi-CA	-1,800	612 (675)	-3 (-3)	-630 (-570)	-17,100 (-15,500)
XIA	CV	Covers	TE, Flu-CA	46,200	612 (675)	80 (70)	-700 (-630)	-11,800 (-10,700)

(continued)

TABLE 8-25. (continued)

Reg. alt.	Storage tanks[a]* Control	Mix room[b] Control	Coating operation[c] Capture, control	Annualized control device cost, $	Emission reduction, Mg/yr (ton/yr)	Cost effectiveness, $/Mg ($/ton) Average[d] Baseline (I)	Baseline (IV)	Incremental[e]
XIA	CV	Covers	TE, Nitrogen[f]	-144,600	612 (675)	-230 (-210)	-720 (-650)	-32,900 (-29,800)
XIA	CV	Covers	TE, Nitrogen[g]	-252,900	612 (675)	-410 (-370)	-740 (-670)	-44,800 (-40,600)
XIB	CV	Fi-CA	PE, Fi-CA	71,000	620 (683)	110 (100)	210 (190)	10,000 (9,100)
XIB	CV	Fi-CA	PE, Flu-CA	111,500	620 (683)	180 (160)	70 (60)	9,000 (8,200)
XIB	CV	Fi-CA	PE, Common	1,200	620 (683)	2 (2)	-550 (-500)	440 (400)
XII	CV	Covers	TE, Inc.	132,800	631 (696)	210 (190)	770 (700)	5,300 (4,800)
XIII	CV	Fi-CA	TE, Fi-CA	49,100	651 (723)	80 (70)	-20 (-20)	-3,400 (-3,100)
XIII	CV	Fi-CA	TE, Flu-CA	97,100	651 (723)	140 (130)	-70 (-60)	-1,400 (-1,300)
XIII	CV	Fi-CA	TE, Common	-20,700	651 (723)	-30 (-30)	-560 (-510)	-6,300 (-5,700)
XIII	CV	Fi-CA	TE, Nitrogen[f]	-93,700	651 (723)	-140 (-130)	-80 (-70)	-9,300 (-8,400)
XIII	CV	Fi-CA	TE, Nitrogen[g]	-202,000	651 (723)	-310 (-280)	-100 (-90)	-13,700 (-12,400)
XIV	CV	Fi-CA	TE, Inc.	183,700	670 (739)	280 (250)	920 (830)	9,300 (8,400)

N/A = Not applicable.

[a] Storage tank emissions controlled by conservation vents (CV) for all regulatory alternatives except baselines.

[b] Mix room emissions controlled by covers with conservation vents or fixed-bed carbon adsorber (Fi-CA).

[c] Coating operation emissions captured by partial enclosure (PE) or total enclosure (TE). Coating operation emissions controlled by separate fluid-bed carbon adsorber (Flu-CA), fixed-bed carbon adsorber (Fi-CA), nitrogen condenser, or incinerator (Inc.), or fixed-bed carbon adsorber controlling emissions from both the mix room and coating operation (Common).

[d] Average cost effectiveness compared to uncontrolled baseline (I) and controlled baseline (IV).

[e] For incremental cost-effectiveness calculations, the same types of control devices were compared to each other. In cases where matching control devices did not occur, the Fi-CA values for the alternative with lower emission reduction were used.

[f] Nitrogen condenser recovering a blend of solvents.

[g] Nitrogen condenser recovering cyclohexanone.

*The costs and control options for solvent storage tanks have been revised. See Tables F-2 and F-6 through F-10 in Appendix F for these revisions.

8.3 REFERENCES FOR CHAPTER 8

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9.0 ECONOMIC ANALYSIS

9.1 INDUSTRY PROFILE

9.1.1 Introduction

The magnetic tape industry is included in two Standard Industrial Classification (SIC) codes: SIC 3573, "Electronic Computer Equipment" and SIC 3679, "Electronic Components Not Elsewhere Classified". Magnetic tape is produced by coating thin plastic film with a mixture of magnetic particles, resins, and solvents. There are three main categories of magnetic tape products: computer, audio, and video. Within each of these categories there are a large number of final products. A summary of these products and their physical parameters was presented earlier in Table 3.1. In the following subsections the various types and use of magnetic tape products are again briefly presented and summarized.

9.1.1.1 Computer. The most important computer recording media products are reel tapes (1.3 cm [1/2 in. wide]), flexible (floppy) disks, digital cassettes, digital cartridges, magnetic cards, and instrumentation tape. Reel tape is generally the least expensive form. It is only used on large-to-medium sized computers. Flexible disks with diameters of 13.3 cm (5-1/4 in.), 20.3 cm (8 in.), and 8.9 cm (3-1/2 in.) are the most recent development in computer recording media and have become quickly accepted because of their relatively low cost and rapid access time. They are generally used on minicomputer or microcomputers as well as word processors. Digital cassettes and cartridges are also used in minicomputers but their use is not as widespread as the flexible disks. Magnetic cards were originally used as a replacement for punched paper cards and their use expanded when the magnetic card was adopted for word processing equipment.[1] However, the use of magnetic cards for word processing is now declining, due to the more common usage of flexible disks and it is expected to disappear altogether. Instrumentation or analog tape was developed in the U.S. and is used primarily by governmental agencies for the monitoring of telemetry and geophysical events.[2]

9.1.1.2 Audio. The three major types of audio tape in order of value of sales are cassettes, 8-track, and open reel. The major formats of 8-track cartridges and cassettes are prerecorded, blank, and institutional, which are used for broadcasting purposes. Most of the cassette tapes are sold as unrecorded or blank tapes, whereas most of the 8-track cartridges are sold as prerecorded tapes. Open reel tape is sold in various size reels. One additional format of open reel tapes is mastering tape, which is used by music and voice recording studios for original sound recording and can later be used for further sound duplication on disks, cassettes, or cartridges. Another minor use of audio tape is its use for sound tracks for TV productions and the movie industry.[3]

9.1.1.3 Video. The video tape market, including the consumer and commercial sector, is relatively new. Although some video products appeared in the market in the mid-70's, domestically produced video tapes were not available until 1977. There are two major types of video cassette tapes for the consumer market: one type for use in the Video Home System (VHS) recorder and one for the Betamax recorder. The VHS format is the more popular of the two. The two systems are not compatible. The consumer video market originally consisted of blank cassettes only, but during the past few years a prerecorded market has developed. In the commercial market, the major tape formats are broadcasting tape and closed circuit TV (CCTV) tape.[4]

9.1.2 Market Structure

9.1.2.1 Identification of Companies and Market Share. The magnetic tape industry consists of firms that coat blank tape only, as well as those that make some of their own coated blank tape but also purchase coated blank tape which they then package into finished products. There are also firms that do not coat any tape but purchase all they need for their finished products. The companies that coat magnetic tape in the United States are listed in Table 3-2. This table presents the company name, location, and type of tape produced. There are 29 facilities, representing 23 companies in 15 states. California has the largest number of facilities (10), representing 34 percent of the U.S. industry. However, on a worldwide basis it is estimated that there are 180 companies that produce magnetic tape products.[5] These firms vary widely in size, ownership, product specialization, and integration, and include companies that produce rigid disks, which are not included in the NSPS. In 1981, 11 companies accounted for 76 percent of worldwide industry sales. Total worldwide sales is divided among Japanese firms, representing 47 percent of total sales, American firms with 33 percent and European companies with the remaining 20 percent.[6]

9.1.2.1.1 Computer recording media. In the United States computer recording media market, three large multinationals dominate the market: IBM, 3M, and Memorex (a division of Burroughs). These three companies make a variety of computer media products. In addition, Verbatim Corporation is also a major manufacturer, although much smaller than the other three firms.

In 1982, the flexible disk market was dominated by IBM, Verbatim, and 3M. In 1983, the four largest producers are expected to be Verbatim, 3M, IBM, and Memorex (including its disk production in Japan) in terms of total production of flexible disks and tape used in flexible disks.[7]

In the 20.3-cm (8-in.) flexible disk market, 3M had the largest share of the world market (36 percent) in 1981 in terms of the quantity of blank magnetic tape produced. The company with the next largest share of this market is IBM with 20 percent, followed by Verbatim with 15 percent. The remaining share of this market is held by foreign firms.

However, in terms of the quantity of finished flexible disks produced, IBM has the greatest share of the world market (20 percent) as well as the U.S. market (26 percent) in 1981. In addition to IBM, the major producers are Verbatim and 3M. The market shares of the companies in this market are shown in Table 9-1.[8] Syncom, a privately owned company, also manufactures flexible disks. Xidex began manufacturing flexible disks in 1981, and distribution began toward the end of 1982.[9] TRI, also privately held, began to manufacture flexible disks in 1983.[10] The remaining companies in the market are foreign producers with 21 percent of the world market.[11]

In the 13.3-cm (5-1/4-in.) miniflexible disk market, a similar situation exists: 3M has the largest share, 48 percent, of the world market for blank magnetic tape used in mini disks followed by Verbatim with 23 percent. However, in terms of production of minidisks Verbatim produces the greatest number of minidisks with 23 percent of the world market and 30 percent of the U.S. market. The other companies with significant shares of this market are presented in Table 9-1.[8] In addition to these companies there are two new companies that either began producing flexible disks after 1981 or plan to produce them in the next few years. Brown Disk Manufacturing Company, incorporated in 1981, manufactured and sold between $10 and $20 million of miniflexible disks in 1983.[12] Memron Co., a newly formed company that packages 5-1/4-in., 8-in., and microflexible disks, plans to begin manufacturing flexible disks in 1985 or 1986.[13] Foreign companies share the remaining 21 percent of the market.[11]

The 8.9 cm (3-1/2 in.) microflexible disk market is a recently emerging market. At the present time there is not a standard size micro disk but a variety of sizes ranging from 3 in. to 3-1/2 in. The major manufacturer is Sony Corp. of Japan but Verbatim and Dysan were expected to begin production of microdisks in 1983.[14]

For 1.3-cm (1/2-in.) computer tapes, 3M and Memorex have nearly equal shares, 21 percent, of the world market. Market shares of other major U.S. producers are shown in Table 9-1. The remaining 11 percent of the market is held by companies located in Japan, France and the United Kingdom.[15]

The data cassette and cartridge market is very small compared to the other segments of the computer recording media market. This market is dominated by two U.S. producers, 3M and Verbatim, although there is some production by European and Japanese firms.[16]

TABLE 9-1. MARKET SHARES OF PRODUCERS OF FINISHED COMPUTER RECORDING MEDIA WITH FACILITIES IN THE U.S. (1981)[10]
(percent)

	Computer Tape		13.3-cm (5-1/4-in.) Disks		8.9-cm (8-in.) Disks	
	Share of world mkt	Share of U.S. mkt	Share of world mkt	Share of U.S. mkt[a]	Share of world mkt	Share of U.S. mkt[a]
Verbatim	-	-	23	30	16	20
3M	21	23	14	18	14	18
IBM Corp.	10	13	5	6	20	26
Dysan Corp.[b]	-	-	15	19	9	11
Memorex	21	26	10	12	7	9
Wabash DataTech	11	13	5	6	8	10
BASF AG	13	8	7	9	5	6
Graham Magnetics	11	14	-	-	-	-
Syncom Corp.	2	2	c	c	c	c
TRI, Inc.	<1	<1	-	-	-	-
Total	89	99	79	100	79	100
Foreign Co.'s	11		21		21	

[a] The U.S. market shares for some companies may be overstated because their output from facilities located in foreign countries is included in the production figures for those firms.
[b] Dysan Corp. does not coat tape but purchases tape from suppliers and converts it into finished products.
[c] NA = data not available.

Two other magnetic tape products are instrumentation tape and magnetic cards. Instrumentation tape is the product of a single manufacturer, the Ampex Corp. Magnetic cards are supplied mainly by IBM, but Memorex and Graham Magnetics are also suppliers.[17]

9.1.2.1.2 Audio tape. In the audio tape market, the leading manufacturer is 3M. Three other large companies in the audio market in decreasing order of sales are BASF, Sony, and Tandy Magnetics. Two other companies are subsidiaries of large multiproduct companies. They are Capitol Industries, a subsidiary of EMI (a British company), and Columbia Magnetics, a division of CBS. Smaller companies in the market include Ampex and Certron Corp. Ampex (1982 sales of $488 million) is a division of Signal and manufactures open reel and mastering tapes. Certron's main business is the design, development, and manufacture of audio magnetic tape products (blank audio cassette tape and 8-track tape). It is a relatively small company with 1982 sales of $23 million.[18] The remaining company, Spectrotape, is privately owned and no information is available about their operations.

9.1.2.1.3 Video tape. The major video tape producers are 3M and Sony. In its annual report, 3M claims to be the world leader in the commercial video tape market.[19] One source reports that 3M has 12 percent of the commercial domestic market.[20] Ampex is another major producer. Tandy and BASF also produce video tape, and the remaining two producers are privately held corporations (Spectrotape and American Video Tape). Additional market share information is not available.

9.1.2.2 Integration. Many of the larger companies in this industry exhibit considerable vertical integration. Companies such as 3M, BASF, Memorex, Tandy, IBM, and Sony produce magnetic tape, package it into finished products (cassettes, tapes, disks, etc.), and sell electronic equipment using the tape. For some of these firms, specifically IBM, Tandy, and Sony, these finished products are produced mainly to support their primary business, which is manufacturing and selling electronic equipment such as computers, stereo equipment, and video recorders. 3M is vertically integrated backward because it produces its own base film and solvents. It holds a unique position in the industry in that it is the largest producer of coated magnetic tape which is used in its own products and also sold to major competitors, such as Dysan and IBM, who in turn produce their own finished products.[21]

In the computer recording media segment, the smaller companies, such as Verbatim, Wabash DataTech, and Graham Magnetics, exhibit very little vertical integration. They purchase raw materials from suppliers and sell the finished product mainly to original equipment manufacturers (OEM) or directly to end users. Typically, OEM's are manufacturers of microcomputer and minicomputer systems, manufacturers of word processors, and software publishers. The finished tape is sold under their own brand name or private label.

There could be a potential problem for smaller manufacturers if the disk drive manufacturers integrate backward. This might be possible because the computer industry is a high growth industry and one opportunity for growth lies in satisfying the growing need for additional storage capacity. Therefore, it is possible that OEM's would choose to expand by entering the magnetic media market.[22] However, the OEM's represent a significant portion of each of the smaller manufacturer's sales; for example, Verbatim sells 52 percent of their product to OEM's [23,24] If the OEM's should decide to integrate backward by producing their own tape, the size of the potential market could be significantly reduced. However, Verbatim is now paying greater attention to the development of its own brand sales, so its dependence on sales to OEM's will diminish.[25]

In terms of horizontal integration, there are several companies that can be considered as horizontally integrated if a narrow definition of the term is used, namely, companies that manufacture more than one type of storage media. Wabash DataTech, for example, manufactures computer tape, 20.3-cm (8-in.) flexible disks, and 13.3-cm (5-1/4-in.) disks. Each of these products serve the same function of storing information, although different hardware is required for each product. Other companies, such as Verbatim, IBM, Memorex, and 3M, also make several types of storage media. If a broader definition of horizontal integration is used (i.e., companies that provide alternate products that serve the same need as magnetic media), then companies such as CBS and Sony must also be included. Sony manufactures video cassette recorders and televisions, both products that serve the same need of providing entertainment. Similarly, CBS through its subsidiary Columbia Magnetics manufactures audio tape as well as making records and films. Again, these are alternate products that satisfy a need for entertainment.

9.1.3 Total Supply

9.1.3.1 Domestic Supply. Production information concerning the magnetic tape industry is difficult to obtain and of uncertain accuracy due to the relative newness of the industry, rapid technological innovations in the product field, and the secretive nature of the industry. The U.S. Department of Commerce compiles production data for the magnetic tape industry. However, the information cannot be used in the analysis because it is not certain as to the type of production data that are represented in the various categories, which implies that double counting may have occurred.[26] The most reliable source of data is Magnetic Media Information Services. Its estimates of the U.S. value of magnetic tape products in the three major categories are shown in Table 9-2. The total value of blank tape coated in the U.S. in 1981 was approximately $1.6 billion, and the value of finished goods was $1.8 billion.[27] The largest segment is the computer recording media market. It shows significant real growth in the value of blank tape in 1981 compared to 1980 of 21 percent. The video tape market has grown much faster than the computer recording media market in the same period, experiencing a 97 percent real growth rate. The audio tape market meanwhile has declined in real terms.

TABLE 9-2. ESTIMATED TOTAL VALUE AND PERCENT OF U.S. PRODUCTION OF BLANK TAPE AND FINISHED AUDIO, VIDEO AND COMPUTER RECORDING MEDIA PRODUCTS, 1980 and 1981[27]

Magnetic Tape Product	Blank Unrecorded Tape			Finished Tape Products
	1980 $ Million[a]	1981 $Million	Real growth (percent)	1981 $ Million[b]
Audio tape (Percent of Total)	317.58 (26.4)	307.11 (19.3)	-3.3	363.48 (20.3)
Video tape (Percent of Total)	277.56 (23.1)	547.62 (34.4)	97.3	685.44 (38.4)
Computer recording media (Percent of Total)	608.33 (50.5)	736.69 (46.3)	21.1	736.69 (41.3)
Total	1,203.47 (100.0)	1,592.42 (100.0)	32.2	1,785.61 (100.0)

[a] 1980 values have been adjusted to reflect 1980 production levels valued at 1981 prices.

[b] Reflects the additional cost and value added of packaging audio and video tape (e.g., cassettes).

Table 9-3 shows the value of the major types of computer recording media for 1981 and 1982. Although the overall growth rate is not as great from 1981 to 1982 as it was from 1980 to 1981, the flexible disk market, particularly the 13.3-cm (5-1/4-in.) flexible disk, has shown very significant growth (85 percent). The flexible disk is considered to be the single most rapidly growing medium of any kind in the magnetic tape industry and such growth is expected to continue.[28]

Computer tape (1.3 cm [1/2 in.]) was manufactured by 11 companies in 1981, 7 of these companies being American, with facilities in the United States and elsewhere. American producers not only dominate the computer tape industry, but the United States is also the largest single market for computer tape. The computer tape segment experienced growth through 1981 but declined during 1982.[29] Data cassettes and cartridges are a small but growing part of the computer recording media market. Instrumentation tape, which is made by the Ampex Corp., is not expected to experience any real growth.[16, 17]

Merchandising Magazine provides information concerning the various formats of audio and video products. However, the shipments and sales data are based on industry-wide estimates rather than the actual output from individual firms in the industry. Information regarding blank (unrecorded) audio shipments and sales is shown in Table 9-4. In the audio tape market during the 1977 to 1982 period, only the cassette segment showed growth. Both open reel and 8-track tape have been declining for several years because of the growing popularity of cassette players. The audio tape market is a mature market, which accounts for its moderate growth.

Information pertaining to blank and prerecorded video tape is provided in Table 9-5. The growth rate for both of these markets has been very great, exceeding 50 percent per year. It is also evident that the VHS format has a significantly larger share of the market, approximately 70 percent, than the Betamax format with 30 percent. Since it began in 1977, the video tape market has also grown to a considerable size. It is a new industry and the market is unsaturated, which explains its considerable growth.

9.1.3.2 Foreign Trade. It is important to recognize that the magnetic tape market is an international market. Although the United States is a major producer of magnetic tape products and the most important consumer of these products, Japan and, to a lesser extent Europe, play a very large role in the magnetic tape market. Worldwide, the total value of coated tape is $4.8 billion, with the largest segment being the video tape market. The video tape market is the largest of the three markets (audio, video, and computer recording media) due in part to the great number of foreign, particularly Japanese, producers in this market.[31]

In Table 9-6 the percentage shares of the major production regions are compared for each magnetic tape category on a yardage basis and a value basis. The United States produces the greatest share of computer

TABLE 9-3. U.S. VALUE OF FINISHED COMPUTER RECORDING MEDIA[30]
(Nominal Dollars)

	1981		1982 (Estimate)		
	Value ($ millions)	Percent to total	Value ($ millions)	Percent to total	Real growth (percent)[a]
13.3-cm (5-1/4-in.) flexible disks	101	14.3	198	23.7	85.0
20.3-cm (8-in.) flexible disks	187	26.5	247	29.6	24.6
Computer tape	358	50.9	328	39.3	-13.6
Data cartridges	36	5.1	40	4.8	4.8
Data cassettes	11	1.6	12	1.4	2.9
Instrumentation tape	11	1.6	10	1.2	-14.2
Total	704	100.0	835	100.0	11.9

[a] Adjusted for inflation by the GNP price deflator (1972 = 100).

TABLE 9-4. QUANTITY AND RETAIL SALES OF BLANK AUDIO TAPE[a], 32-35

	1977		1978		1979		1980		1981		1982		
	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Compound annual growth rate: (percent)
Audio													
Cassette	200,000	$324,000	220,000	$564,000	203,986	$399,509	218,689	$487,676	228,147	$542,990	236,344	$562,499	3.4
Open reel	12,250	41,895	11,000	69,100	9,200	72,558	8,864	74,812	8,018	70,077	7,567	64,092	-9.2
8-track	33,840	70,387	32,000	77,000	21,600	39,192	17,194	32,324	10,228	16,058	7,870	12,828	-25.3
Total	246,050	$436,282	263,000	$710,100	234,786	$511,259	244,747	$594,812	246,393	$629,125	251,781	$639,419	0.5

[a] Shipments and sales are based on industry-supplied estimates rather than the actual output from individual firms in the industry.
[b] Units are not a standard size.

TABLE 9-5. QUANTITY AND RETAIL SALES OF BLANK AND PRERECORDED VIDEO TAPE[a,35,36-38]

	1977		1978		1979		1980		1981		1982		Compound annual growth rate: (percent)
	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	Units[b] shipped (000)	Retail sales (000)	
Blank Video Tape													
Beta	2,000	--	3,000	$45,000	4,567	$ 73,072	6,028	$ 90,420	9,361	$128,058	12,207	$158,691	43.6
VHS	1,000	--	2,500	50,000	5,400	102,600	9,288	167,184	17,350	281,591	26,216	393,240	92.2
Total	3,000	$ 42,000	5,500	$ 95,000	9,967	$175,672	15,316	$257,604	26,711	$409,649	38,423	$551,931	66.5
Prerecorded Video tape													
Beta	c	c	--	--	906	62,514	1,123	69,626	1,643	111,724	1,960	113,288	29.3
VHS	c	c	--	--	1,252	91,396	2,028	139,932	3,529	268,204	4,550	293,930	53.7
Total	c	c	1,200	--	2,158	$153,910	3,151	$209,558	5,172	$379,928	6,510	$407,218	52.6

[a] Shipments and sales are based on industry-supplied estimates rather than the actual output from individual firms in the industry.
[b] Units are not a standard size.
[c] Sales of prerecorded video tapes began in 1978.

TABLE 9-6. WORLD PRODUCTION OF MAGNETIC TAPE BY GEOGRAPHIC REGION[31]

(Percent)

	Based on yardage of coated tape				Based on value of coated tape			
	Audio	Video	Computer recording media	Total	Audio	Video	Computer recording media	Total
U.S.A.								
1981	23.8	26.4	80.7	33.9	17.9	25.0	82.2	33.0
1980	21.8	24.2	80.5	35.1	18.8	23.2	85.5	40.9
Japan								
1981	27.2	59.2	1.8	33.4	49.7	58.6	4.0	46.6
1980	39.4	69.1	1.2	37.9	49.4	67.1	4.2	40.3
Europe								
1981	22.9	13.4	17.4	18.9	18.0	12.3	13.7	14.7
1980	24.9	5.9	18.3	15.7	21.9	5.9	10.3	13.7
Rest of World								
1981	26.1	1.0	0.1	13.8	14.4	4.1	0.1	5.7
1980	13.9	0.8	-	11.3	9.9	3.8	-	5.1

recording media (80 percent of the market) but is surpassed by Japan in the production of audio and video tape. The Japanese hold approximately 60 percent of the video tape market but Japanese production appears to be declining.[31] The Japanese share of coated audio tape also fell but its share on a value basis remained constant. Japanese producers are apparently losing their market share of video tape as more companies enter the market, but are able to keep audio prices high despite their loss of market share on a yardage basis.[39]

Table 9-7 shows the total production of flexible disks by major producing regions. Although the United States produces the majority of flexible disks, the U.S. has lost considerable market share to Japan between 1979 and 1982. It is estimated that the Japanese produced only 4 percent of the total supply of flexible disks in 1979 compared with 22 percent in 1982. The market for flexible disks in Japan has been very small, but as word processors become more common in Japan it is expected that flexible disk usage will grow very rapidly. It is expected that Japanese production of flexible disks will increase to meet the growing demand both in Japan and in other markets. Although the United States is presently a large exporter of flexible disks, by 1985 it is predicted that the U.S. will be an importer with most of the imports being miniflexible and microflexible disks produced in Japan.[40]

9.1.4 Total Demand

9.1.4.1 Demand by End Use. The data processing industry has experienced exceptional growth in recent years. Because of the link between computers and storage devices, the demand for magnetic media products follows computer sales. The trends in sales related to computer capacity are of particular importance because such trends dictate media requirements. Over the last 5 years, sales of mainframe computers have been losing their market share to minisystems and microsystems. This trend is apparent in Table 9-8, which shows the sales of different types of computers from 1979 to 1980. This increase in growth of the minicomputers and microcomputers has influenced the growth rate of products servicing these markets. The use of flexible disks for small computers and for word processors has increased dramatically since their introduction by IBM in 1973.[41] Flexible disks were readily accepted because of their low cost and rapid access time. This trend will be strengthened by the introduction of the personal computers, which are basically microcomputers and are used by small businesses as well as in households. The large computers still dominate the market in terms of dollar sales but their growth rate is significantly less than the other categories. Although the computer tape market is a very large market with considerable demand, it is a mature market that is expected to reach a peak in demand by 1983-84 followed by a rapid decline starting in 1987 as a new generation of tape products enter the market. These new products will include new types of computer tape, which will have higher capacity than the current format, together with new drives on which to use them.[44]

TABLE 9-7. ESTIMATED WORLD PRODUCTION OF FINISHED FLEXIBLE DISKS BY GEOGRAPHICAL AREA, 1979-1982[42]
(Million Units)

	1979	1980	1981	1982 (Estimate)
United States	43	78	124	183
(Percent of World)	(91.4)	(85.7)	(78.0)	(71.7)
Japan	2	9	26	56
(Percent of World)	(4.3)	(9.9)	(16.4)	(22.0)
Europe	2	4	9	16
(Percent of World)	(4.3)	(4.4)	(5.6)	(6.3)
World (Total)	47	91	158	255
	(100.0)	(100.0)	(100.0)	(100.0)
By Size of Disk				
5-1/4 in.	11	25	67	140
(Percent of World)	(23.4)	(27.5)	(42.4)	(54.9)
8 in.	36	66	91	115
(Percent of World)	(76.6)	(72.5)	(57.6)	(45.1)
Total	47	91	158	255

TABLE 9-8. SALES OF COMPUTERS BY MAJOR CATEGORIES[43]
(Nominal dollars)

Computer category	1979 (Million)	1979 Share of market (percent)	1980 (Million)	1980 Share of market (percent)	Real growth[a] (percent)
Mainframes	$13,312	62.8	$15,148	59.1	4.1
Minicomputers	6,916	32.7	8,840	34.5	16.9
Microcomputers	416	2.0	769	3.0	69.2
Word Processors	538	2.5	881	3.4	49.8
Total	$21,182	100.0	$25,638	100.0	

[a] Adjusted for inflation by the GNP price deflator (1972 = 100).

In the audio equipment market, of the three major products (cassette, 8-track, and open reel), only cassette equipment has shown an increase in demand during the 1978 to 1982 period as shown in Table 9-9. Cassette players continue to be popular in all formats with portable tape units having the largest share of the market. Sales of 8-track equipment have declined significantly due to the increasing popularity of the cassette players. The open reel players are found only in the more sophisticated tape decks and have also declined in sales.

As expected, the demand for blank audio cassette tapes is much greater than either open reel or 8-track tape, as was shown in Table 9-4. There are two types of audio cassette tape: premium and promotional or low budget cassette tapes. The promotional tape is generally marketed for the teenage population, but as this teenage population declines in size, so have the sales of promotional tape. As a result, there is greater demand for premium tape; this trend is expected to continue.[45] Other reasons for the greater popularity of premium tapes are consumer dissatisfaction with low budget tapes and a general increase in the income of people who purchase more expensive high fidelity equipment.

The demand for video tape has changed considerably in recent years with the availability of consumer video cassette recorders (VCR's) beginning in 1976. Between 1978 and 1982, the number of VCR's shipped by manufacturers increased fivefold from approximately 400 thousand units in 1978 to more than 2 million in 1982.[33] The demand for video tapes has been growing dramatically following the trend of rising purchases of VCR's. The greatest demand is for the VHS format, with approximately 70 percent of the market, as compared to 30 percent for the Beta format.[46] It was estimated that in 1977 approximately 56 percent of video tape manufacturer sales went to the consumer market, 27 percent to video duplicators, 11 percent to governmental agencies, and 6 percent to large industrial customers.[47] Although a more recent distribution of sales is not available, present sales to the consumer market probably make up 80 percent of the market and sales to duplicators 20 percent.[48]

9.1.4.2 Elasticity of Demand. Magnetic tape products and the hardware (computer equipment, and audio or video recorders) are complimentary products whose demand is derived from the desire or final demand for information storage and entertainment services. However, the demand for magnetic tape is also dependent upon the price and availability of the hardware.

Demand for commercial computer tape is likely to be quite inelastic, reflecting the relatively fixed number of large computers with tape drives. Tape represents only a small portion of the cost of the computer output and therefore the amount of tape used is less sensitive to price than the availability of the hardware. Also, there are few alternative products that can be used. This situation is similar for specially designed flexible disks required by many of the smaller

TABLE 9-9. SHIPMENTS OF AUDIO EQUIPMENT[33]
(No. of units; 10^3)

	1978	1979	1980	1981	1982	Compound annual growth rate (percent)
Cassette equipment						
Automotive	2,955	3,580	3,913	4,228	4,576	
Tape decks	440	495	545	634	707	
Compact high fidelity	383	1,308	1,470	1,501	1,648	
Portable tape Units	14,579	19,141	22,411	27,226	27,346	
Total	18,357	24,524	28,339	33,589	34,277	16.9
8-Track equipment						
Automotive	4,700	4,300	3,096	2,638	2,012	
Tape decks	95	72	68	60	49	
Compact high fidelity	3,741	2,765	2,242	1,877	1,158	
Portable tape units	1,598	1,157	955	867	704	
Total	10,134	8,294	6,361	5,442	3,923	-21.1
Open reel equipment						
Tape decks	115	108	103	90	80	- 8.7
Total all equipment	28,606	32,926	34,803	39,121	38,280	7.6

computers. Rigid disks are an alternative storage media in many situations but flexible disks have similar capabilities at less cost.

The demand for commercial audio tape (i.e., mastering tape) and video tape (i.e., broadcasting tape) is also likely to be inelastic. However, the consumer market for video products is growing rapidly and therefore will play a more important role in determining elasticity of demand.

For all three segments of the magnetic tape industry, demand for consumer magnetic tape products is more elastic than demand for commercial magnetic tape products. This situation exists for two reasons: (1) consumer magnetic tape products, such as video games, video movies, computer games, and audio cassettes, are luxury items, not necessities; and (2) there are a variety of substitute products for these items such as records, commercial or cable TV, radio, and movie theatres. Therefore, the consumer has other options to choose from or can refrain altogether from purchasing magnetic tape products.

9.1.4.3 Substitutes and New Technologies. Substitutions in all segments of the magnetic tape industry are made on the basis of the characteristics of either the hardware or various magnetic tape products. Once a hardware decision has been made, no substitutions among tape products are possible; the magnetic tape product is dictated by the hardware drive unit. However, hardware choices themselves are sometimes dictated by a preference of one type of magnetic tape product over another on the basis of handling, physical storage requirements, storage capacity, and cost. In the video market, substitutions also exist as a result of competition with movies and television. This market is relatively new so it can be expected that new technologies will be emerging.

New technologies are continuously emerging in the computer and video industry. In the computer industry, there is a trend to increase the storage capacity of the established sizes of flexible disks and to decrease the size of the flexible disk drives.[49] Another important development is the microflexible disk which is expected to be a major factor in the overall flexible media field beginning in 1983 or 1984.[50]

There are many new technologies that are in various stages of development in the computer media industry. Two of these alternate technologies are important because they may be a threat to the magnetic media industry in the future:[51]

1. Optical mass storage systems. These systems use laser technology and have storage densities approximately 1,000 times greater than magnetic media. There are still major hardware and software problems to be resolved before they can be available for general use.

2. Semiconductor memories. Random access memories (RAM) provide extremely fast access time, about a million times faster than

magnetic media. However, the storage capability is significantly less than presently available magnetic media, and the cost is much higher.

In the video market, one new development is the video disk player, which uses optics for storage and play. Current demand for the video disk player is not known, but one source estimates that by 1988, 18 million homes in the U.S. will have video disk players as compared to 13 million homes which will have video tape recorders.[52]

9.1.5 Prices

Prices for various magnetic tape products vary significantly because they are not homogeneous products. The prices vary according to the market, quantity purchased, and quality as well as according to distribution outlet (manufacturer, distributor, or retailer). Table 9-10 shows the wholesale or distributor price for a variety of magnetic tape products for 1983. These prices were obtained by directly contacting several distributors. Manufacturers' prices are not available due to the secretive nature of the industry. There are a considerable number of products, so only selected products under each category are included. These prices are for products from a variety of manufacturers. The prices for magnetic tape products are generally similar from one manufacturer to another although there are regional price differences. Price differences for the same product can generally be attributed to quality differences or to specialized product specifications. There are some audio tapes, for example, which can be used for a variety of purposes and others that are specifically manufactured for a particular use such as high fidelity recording. Although these are wholesale prices, the high price that is listed can be used as an approximate retail price for many of the products because of price cutting at the retail level.

In the computer segment of the industry, product quality is of critical importance. Any flaw in the product could result in stored information being lost or data being misinterpreted. As a result, the user could incur a very significant expense. A company with a poor reputation for quality would find it difficult to compete. Therefore, an unusual relationship exists between price and quality in that quality is of paramount importance. Price is of less importance than quality to both equipment suppliers and end users.[25] However, there is significant price competition in the computer recording media industry, particularly in the flexible disk market. For example, prices for 13.3-cm (5-1/4-in.) miniflexible disks fell in 1982 compared to 1981 as a result of a large increase in production of the miniflexible disk. This relieved competitive pressures on pricing for the 20.3-cm (8-in.) disk. Prices for 20.3-cm (8-in.) flexible disks have remained stable. Prices for 1.3-cm (1/2-in.) reel tape have been stable because it is a relatively mature market. Data cassettes and data cartridges are expected to experience increased demand which will cause prices to rise but after 1987 these products will probably decline in use.[53]

TABLE 9-10. DISTRIBUTORS' PRICES OF SELECTED FINISHED MAGNETIC TAPE PRODUCTS[a], [54-56] (1983)

	Range of prices ($/Unit) (nominal)	
	Low	High
Audio		
Open Reel		
18-cm (7-in.) Plastic reel; 549-m (1,800-ft); EE Format	10.10	11.95
27-cm (10-1/2-in.) Metal reel; 1,097-m 3,600-ft); EE Format	26.50	32.65
18-cm (7-in.) Plastic reel; 366-m (1,200-ft); backcoated	5.85	6.75
27-cm (10-1/2-in.) Metal reel; 762-m (2,500-ft); backcoated	16.40	18.28
8-Track		
46 minutes	2.03	2.32
60 minutes	2.27	2.52
90 minutes	2.56	2.74
Cassettes		
46 minutes; metal	2.69	5.25
60 minutes; metal	2.96	5.83
60 minutes; normal bias	1.10	2.59
90 minutes; normal bias	1.52	4.39
120 minutes; normal bias	1.96	4.11
Video		
VHS		
T30: 1 h running time	7.20	10.15
T60: 2 h running time	8.17	11.92
T90: 3 h running time	9.03	13.05
T120: 4 h running time	9.69	14.85

continued

TABLE 9-10. Continued

	Range of prices ($/Unit) (nominal) Low	High
Beta		
L250: 1 h running time	5.53	8.77
L500: 2 h running time	7.68	11.66
L750: 3 h running time	9.34	14.10
Computer		
Floppy Disks		
20.3 cm (8-in.) single sided		3.60
20.3 cm (8-in.) double sided		4.20
13.34 cm (5-1/4-in.) single sided	2.60	3.38
13.34 cm (5-1/4-in.) double sided	3.70	4.20
Data Cassettes		
10 minutes		1.55
15 minutes		1.70
90 minutes		3.93

[a] The products listed include some but not all of the magnetic tape products within each category. These products represent a variety of manufacturers and a range of quality specifications. Generally, the low end of the price range represents a lower quality product while the high end represents a higher quality or a more specialized product. If a range of prices is not available (i.e., only price data for one manufacturer and one product type is known), then a single price (high) is shown.

Competition in the magnetic media industry is very strong. Retail prices of audio and video products are shown in Table 9-11. These prices are derived from industry estimates of total retail sales and number of units shipped shown in two earlier tables (Tables 9-4 and 9-5). They are average prices representing a variety of products within each category; they do not represent the prices of any particular brand. Prices for cassettes and 8-track show little movement during the 1977 to 1982 period while open reel prices have increased. Over a long period of time, strong price competition would cause the overall trend in prices to be relatively stable, although specific product prices may fluctuate significantly in the short term. These fluctuations are mainly a result of price wars and/or the entry of new products.

Particularly in the audio segment there is extensive price competition from suppliers from Japan and Hong Kong in the lower quality promotional tape products.[57] These suppliers reduce their prices of the lower quality tape in order to maintain sales volume and their market share.[58] Price increases that have occurred are a result of inflationary pressures. For one company, Certron, the prices of its promotional audio cassettes declined during 1982 due to foreign competition but prices increased for its higher quality products.[59]

In the video market, an unusual situation occurred through 1981 in that although demand for video tape far exceeded supply, prices at the retail level declined. Despite the higher prices that retailers could get for videotapes, prices were evidently discounted to increase the physical volume of video tape and recorders sold in order to enhance the future growth in the demand and sales of video tape products. However, by 1982 prices appeared to be leveling off, although some companies with new factories lowered prices in order to enter the market.[60] The supply problem in 1982 was less severe, but price cutting at the retail level still occurred, particularly for lower quality tape. One manufacturer felt that June 1982 retail prices, which ranged from $12 to $15 per tape, represented the lowest level to which prices would fall.[46]

The price situation of video tape is most likely related to the supply and demand characteristics of video cassette recorders. Since the introduction of VCR's in the late 1970's, sales have been increasing significantly. However, by 1982 an oversupply of VCR's occurred which was attributed to the flood of Japanese imports and the recession. This situation resulted in significant price reductions for VCR's.[61] Therefore, the price cutting for tape products that occurred in 1982 is a reasonable reaction to the pricing situation of VCR's.

9.1.6 Growth Projections

9.1.6.1 Projected Product Demand. The U.S. magnetic tape manufacturing industry should experience significant growth over the 5 years. There will be different rates of growth, however, within each segment of the industry (audio, video, and computer).

TABLE 9-11. DERIVED RETAIL PRICES OF BLANK AUDIO AND VIDEO TAPE[a]
Nominal ($/Unit)

	1977	1978	1979	1980	1981	1982
Audio tape						
Cassette	1.62	2.55	1.96	2.23	2.38	2.38
Open reel	3.42	6.28	7.89	8.44	8.74	8.47
8-Track	2.08	2.41	1.81	1.88	1.57	1.63
Video tape						
Beta	b	15.00	16.00	15.00	13.68	13.00
VHS	b	20.00	19.00	18.00	16.23	15.00

[a] Nominal prices were derived from Tables 9-4 and 9-5 by dividing reported retail sales by the total number of units shipped.

[b] Not available.

The projected growth rates for the various computer storage media products are shown in Table 9-12. It should be noted that these growth projections are based upon the opinions of various experts and therefore, some degree of uncertainty should be attached to these growth estimates. All categories show significant growth except for cassettes, which show a decline. As expected, flexible disks, in particular the 13.3-cm (5-1/4-in.) disk, are projected to show the largest growth during the 5-year period from 1980 to 1985. Their share of the market should increase to the point where flexible disk sales will represent more than half of the market. The growth rate for computer tape in the 1980's is expected to be only moderate because mainframe computers have been losing their share of the market to the minicomputers and microcomputers. The overall real growth in volume for the computer media market should be substantial, approximately 20 to 25 percent on an annual basis.

The audio tape market is a mature market with only the cassette segment showing moderate growth. The 8-track and open reel markets have been declining over the years, as shown on Table 9-4. The cause of this decline is primarily competition from cassette tapes, which are equal in quality, competitively priced, and more compact. Because the overall growth in the audio equipment market has been small (see Table 9-9), the overall real growth of the audio tape market will probably be relatively small.

The video media market is still in the early stages of development and has experienced tremendous growth in recent years. From 1978 to 1982, there was a 50 percent annual growth rate in the number of VCR units shipped. Therefore, an equivalent increase in demand for video tapes during this period might be expected. It is expected that high growth will continue throughout the decade. However, the growth rate for future sales is likely to decline as the market matures. Different sources of data provide a variety of estimates of growth rates for blank video tape. Most of these estimates range from 25 to 40 percent per year.[63-67] These estimates are based mostly on unit sales increases, so they are expressed in real terms. A conservative estimate of the growth in volume for this market is approximately 25 percent per year.

9.1.6.2 Projected New Sources. An estimate of the number of new sources in the magnetic tape industry was made based upon information from 20 of the 29 plants in the industry. These plants provided estimates of their expansion plans between 1984 and 1989. Fifteen plants (75 percent) responded that they planned to build at least one new line. The total number of new lines projected by the 15 plants was 20, or an average of 1.3 new lines per plant. In order to project the total new lines industry wide, these factors can be applied to the 29 plants in the industry. If it is assumed that 75 percent, or 22 plants, would each be adding 1.3 new lines, then there would be a total of 28 new lines by 1989. Of the 28 new lines, 7 lines are expected to be constructed in 1984, before proposal of the NSPS. These lines are subtracted from the projected 28 new lines resulting in a projection of

TABLE 9-12. GROWTH OF FINISHED COMPUTER STORAGE MEDIA, BY TYPE[62]

Computer storage media	1980 ($ Million)	1980 Share of market (Percent)	1985 ($ Million)	1985 Share of market (Percent)	Compound annual real growth rate[a]
Tape 1.3 cm (1/2 in.)	368.0	64.3	668.5	41.7	12.7
Flexible disks	168.7	29.5	825.9	51.5	37.4
13.3 cm (5-1/4 in.)	41.2		586.5		70.1
20.3 cm (8 in.)	127.5		239.4		13.4
Subtotal	168.7		825.9		
Data cassette	13.6	2.4	10.5	.7	-5.0
Digital cartridge	22.0	3.8	98.7	6.1	35.0
TOTAL	$572.3	100.0	$1,603.6	100.0	22.9

[a] It is assumed that the same base prices are reflected in the 1980 and 1985 figures.

21 new lines to be regulated under the proposed NSPS. Based upon industry information, six (27 percent) of the new lines will be 6 in. in width, eight (40 percent) will be in the 12 or 13 in. range, and seven (33 percent) will be in the 20 to 26 in. range. It is estimated that 1 (5 percent) of the new lines will be used for research and 20 (95 percent) of the new lines will produce primarily video and computer recording media products. Due to the very small growth rate anticipated for the audio tape market, no new lines are expected to be used for audio tape production.

9.1.6.3 Reconstruction and Modification of Sources. No major additions to the equipment or changes in the process that would be subject to regulation by the proposed NSPS are projected for the next 5 years. It is very difficult to estimate the actual useful life, and therefore the need for replacement of magnetic tape coating equipment. Most of the existing equipment in the magnetic tape coating industry is less than 15 years old, but some lines are 30 years old and are still operating. Similar process equipment in other web coating industries has a life span of 20 to 30 years, but 50-year-old equipment is still in operation.[68-72] Generally, owners tend to maintain and repair existing lines rather than replace entire lines. For these reasons, no modification and reconstruction is projected for the next 5 years. Definitions of reconstruction and modification are discussed in greater detail in Chapter 5.

9.1.7 Financial Profile

Financial information for the years 1980 through 1982 for most of the companies in the magnetic media industry is presented in Table 9-13. There are an additional 6 companies that do not appear in this table because no information is available. These 6 companies are all privately held and are as follows: American Video Tape, Spectrotape, Syncom, TRI, Brown Disk Manufacturing Company, Inc., and Malco Plastics Co.

Some of the companies listed in Table 9-13 did not provide data regarding their tape producing subsidiaries. In these cases, financial data for the parent company are presented. All of the companies, large and small, show a strong financial position as evidenced by their return on sales ratio (operating profit/revenues) and return on investment ratio (operating profit/assets). Although 1982 was not as profitable as previous years for many of these companies, their financial position is still strong.

9.2 ECONOMIC IMPACT ANALYSIS

9.2.1 Introduction

The following sections examine the economic impact of the proposed magnetic tape New Source Performance Standard (NSPS) on the audio, video, and computer recording media products markets. Model plants are

TABLE 9-13. KEY FINANCIAL STATISTICS FOR MAGNETIC TAPLE PRODUCING COMPANIES[73-90]

		Ampex		BASF	Capital Ind.	Certron Corp	Columbia Magnetics
		($ Million)	Total for consolidated firm: Signal ($ Million)	($ Million)[a]	Total for consolidated firm: EMI (UK)[a,b] ($ Million)	($ Thous.)	Total for consolidated firm: CBS[b] ($ Million)
Revenues	1982	488.0	4,935.6	c	7,835.1	23,704.0	4,122.8
	1981	518.0	5,342.6	12,341.1	7,107.9	23,463.0	3,955.1
	1980	496.8	4,782.1	10,773.5	c	22,784.0	3,852.0
Revenues for Tape Segment, if applicable	1982			c			
	1981			78.2			
	1980			c			
Profits before taxes	1982	23.3	113.2	c	158.0	620.0	313.5
	1981	43.9	214.0	501.3	141.4	794.0	401.8
	1980	52.3	175.9	493.7	c	699.0	417.2
Assets	1982	409.7	3,606.7	c	2,591.9	11,631.0	2,682.9
	1981	395.6	3,678.6	7,724.9	2,364.5	10,679.0	2,413.8
	1980	379.3	3,482.1	7,102.6	c	10,684.0	2,299.8
Operating profit/ revenue (percent)	1982	4.8	2.3	c	2.0	2.6	7.6
	1981	8.5	4.0	4.1	2.0	3.4	10.2
	1980	10.5	3.7	4.6	c	3.1	10.8
Operating profit/ assets (percent)	1982	5.7	3.1	c	6.1	5.3	11.7
	1981	11.1	5.8	6.5	6.0	7.4	16.6
	1980	13.8	5.1	7.0	c	6.5	18.1

continued

TABLE 9-13. Continued

		Graham Magnetics, Inc.		IBM	Memorex	NCR	Pfizer	Sony
		($ Million)	Total for consolidated firm: Carlisle Corp. ($ Million)	($ Million)	Total for consolidated firm: Burroughs Corp. ($ Million)	($ Million)	($ Million)	($ Million)[a]
Revenues	1982	70.5	377.9	34,364.0	4,186.3	3,526.2	3,453.6	c
	1981	72.5	406.3	29,070.0	3,405.4	3,432.7	3,249.7	4,566.9
	1980	62.1	380.8	26,213.0	2,902.4	3,322.4	3,029.3	3,877.8
Revenues for Tape Segment, if applicable	1982			158.2	154.51[d]			
	1981			133.9	146.19[d]			
	1980			c	c			
Profits before taxes	1982	10.2	42.3	7,930.0	75.1	429.8	544.2	c
	1981	13.0	66.6	6,260.0	254.1	358.2	437.3	551.9
	1980	8.6	48.7	5,723.0	134.4	456.4	410.0	502.9
Assets	1982	33.9	288.5	32,541.0	4,123.1	3,373.0	3,748.7	c
	1981	32.6	225.7	29,107.0	4,439.4	3,386.5	3,647.1	4,955.6
	1980	32.4	196.3	26,831.0	3,854.7	3,366.5	3,363.7	3,779.5
Operating profit/revenue (percent)	1982	14.5	11.2	23.1	1.8	12.2	15.8	c
	1981	17.9	16.4	21.5	7.5	10.4	13.5	12.1
	1980	13.8	12.8	21.8	4.6	13.7	13.5	13.0
Operating profit/assets (percent)	1982	30.1	18.5	24.4	1.8	12.7	14.5	c
	1981	39.9	29.5	21.5	5.7	10.6	12.0	11.1
	1980	26.5	24.8	21.3	3.5	13.6	12.2	13.3

continued

TABLE 9-13. Continued

		Tandy Corp.	3M	Verbatim	Wabash DataTech, Inc.		Xidex Corp.
						Total for consolidated firm: Kearny-National, Inc.	
		($ Million)	($ Million)	($ Million)	($ Million)	($ Million)	($ Million)
Revenues	1982	2,061.2	6,601.0	85.1	51.2	177.4	93.4
	1981	1,707.1	6,508.0	53.8	48.9	186.5	73.4
	1980	1,396.0	6,080.0	50.1	c	60.9	58.5
Revenues for Tape Segment, if applicable	1982		880.0				
	1981		690.0				
	1980		533.0				
Profits before taxes	1982	423.4	1,014.0	13.9	6.5	14.2	21.9
	1981	320.6	1,153.0	1.1	12.0	13.6	16.0
	1980	210.7	1,185.0	1.8	c	5.2	12.1
Assets	1982	1,227.6	5,514.0	59.3	47.6	119.1	90.0
	1981	936.5	5,422.0	39.1	43.0	123.0	79.7
	1980	710.3	5,061.0	36.1	c	55.1	c
Operating profit/ revenue (percent)	1982	20.5	15.4	16.3	12.7	8.0	23.4
	1981	18.8	17.7	2.0	24.5	7.3	21.8
	1980	15.1	19.5	3.6	c	8.5	20.7
Operating profit/ assets (percent)	1982	34.5	18.4	23.4	13.7	11.9	24.3
	1981	34.2	21.3	2.8	27.9	11.1	20.0
	1980	29.7	23.4	5.0	c	9.4	c

[a] Foreign exchange rate used as of October 7, 1983:
U.S. $1.00 = 2.574 Gr. marks
U.S. $1.00 = .667 Br. pounds
U.S. $1.00 = 232.15 Jap. yen

[b] No financial information available for tape segment.

c = Not available.

[d] Includes computer recording media only, not audio or video tape products.

developed to represent facilities in these three markets and used to compute the impact of the compliance costs on the industry.

Section 9.2.3 presents an analysis of the market conditions for each of the three magnetic tape markets. Model plant parameters are developed in Section 9.2.4 and baseline costs explained. Section 9.2.5 discusses the selection of regulatory alternatives to be included in the analysis. In Section 9.2.6 estimates of the economic impacts of the NSPS are provided for each of the three markets. The final Section 9.2.7 discusses the ability of firms to afford the necessary capital expenditures associated with the NSPS.

9.2.2 Summary

An NSPS regulation will increase the capital and operating costs for new facilities in the magnetic tape industry relative to existing magnetic tape production facilities because additional control equipment will have to be installed. As a result, certain changes can be expected in the three magnetic tape markets (audio, video, and computer recording media products).

Little or no growth is forecast for the audio tape market (as discussed in Section 9.1.6.), so it can be assumed that additional lines will not be added at existing facilities nor will new facilities be built. Therefore, the proposed NSPS will not affect the audio tape market. However, in the event that a new source enters the market, production costs are likely to increase from less than 1 percent to 2.69 percent depending upon the size of the operation and type of installed control device. At the retail level these additional production costs are likely to boost product prices from 0.2 percent to 0.5 percent if all costs are passed forward. These increases are minimal and would have little impact on production, consumption, or employment in the industry.

The video tape market, however, is growing at a significant rate; 21 new lines for the production of both video and computer recording media products are expected over the next 5 years. Because foreign competition is a major factor in this market, it is expected that most of the compliance costs will be absorbed by the industry. Production cost increases as a result of the NSPS would range from 0 to 0.5 percent depending upon the regulatory alternative selected, the size of the line and the initial baseline. When added to other production and marketing costs including a reasonable profit margin, the impact of the NSPS on retail prices is negligible, ranging from 0.2 to 0.4 percent.

The computer recording media market is also in a high growth stage but foreign competition is not significant at present. Therefore, manufacturers are expected to pass along most or all of the cost increases to the consumer. The increases in production costs range from 0 to 0.27 percent depending upon the regulatory alternative and the size of the line. The additional production costs are likely to have no impact on retail prices. Foreign competition will become significant by the mid-to-late 1980's, forcing manufacturers to start absorbing the control costs.[91] Again, because the costs are relatively small, production, consumption, and employment should not be affected.

In summary, the costs of compliance for all regulatory alternatives appear to be feasible without any significant adverse economic impact on most firms in the magnetic tape industry. Most new capacity is likely to be added by well established existing firms in the industry, which are less likely to suffer from financial hardship in complying with the standard.

9.2.3 Market Analysis

The impacts of the proposed NSPS can be judged by examining the effects on the individual markets for magnetic tape products. The three types of magnetic tape products exist in different markets, implying that the audio, video and computer recording media markets will behave in different ways as a result of the NSPS. Different types of market impacts are evaluated in this analysis. One is the effect on costs at the manufacturing level and the resultant effect on consumers due to a retail price change. Another type of impact is the effect on the quantity of magnetic tape products produced and consumed in the U.S. In a competitive industry, an increase in prices would result in some degree of decreased demand depending upon the price elasticity of demand. Therefore, output and consumption will be affected to a greater or lesser degree as a result of a change in prices and the demand elasticities of the product. Also, the additional costs that magnetic tape plant facilities will incur to implement the NSPS may influence companies' decisions to build new plants or increase production by adding additional lines. If new plant investment or increased production is curtailed, industry employment will fall below what it would have been without the regulation. The following subsections describe the impacts that will occur in each of the three magnetic tape markets.

9.2.3.1 Audio tape market. The audio tape market has experienced little growth since 1977. Except for audio cassettes, most segments of this market have not grown or have declined. Minimal growth, together with strong foreign competition, particularly from Japan, is expected to discourage any additional production lines or new facilities for the production of audio tape in the foreseeable future.

9.2.3.2 Video tape market. In contrast, the video tape market is growing at a rapid rate; it is anticipated that new lines will have to be built to meet the growing demand. The proposed NSPS will impose additional costs on companies that build new lines, costs that will either be passed forward to the consumer or absorbed by the company, depending upon market conditions. These costs can be measured by computing the annualized costs of the NSPS as a percent of total costs. The results of this computation are discussed in Section 9.2.6.2.

The video tape market is characterized by significant foreign competition. In 1981, close to 60 percent of total worldwide video tape production was Japanese.[31] It is unlikely, then, that U.S. producers would pass the control costs forward in the form of a price increase because they would lose their share of the world market. Since foreign companies will not be affected by the NSPS or a comparable regulation, it can be expected that U.S. companies will either absorb the compliance costs or delay their entry into the market until such time that the price of tape products increases sufficiently to cover the costs of compliance. Due to the increasing demand in the market, prices will probably remain high during the next few years and firms will likely proceed with expansion plans while absorbing some of the compliance costs. The impact of absorbing the compliance costs is not significant and is discussed in Section 9.2.6.2. If some domestic companies do delay their expansion plans, then it can be expected that foreign companies will increase production to fill the gap. This increase in imports would result in a negative effect on U.S. balance of payments. In this situation there would be a slight reduction in the quantity produced in the U.S. but little impact on worldwide consumption of video tape products.

9.2.3.3 Computer recording media market. The computer recording media market is also experiencing significant growth, particularly the flexible disk segment of the market. In order to meet the anticipated demand, additional lines will have to be built and compliance costs either passed forward or absorbed. The computer recording media market is different than the video tape market in that foreign competition does not now play as large a role. Most computer tape is produced in the U.S., and at the present time, the U.S. is also the major producer of flexible disks. Since the U.S. has a major share of the market and demand is relatively inelastic, it is expected that a small price increase could be passed forward to consumers without any significant impact on the quantity sold.

In contrast to the current situation of little foreign competition, by the mid-to-late 1980's Japan is expected to capture a significant share (approximately 25 percent) of the flexible disk market.[91] Therefore, it is more likely that a greater proportion of the compliance costs are likely to be absorbed by domestic producers as new facilities are built because of increased foreign competition. It is unlikely that expansion plans would be delayed because: (1) such a delay would result in further erosion of the market position of domestic producers, and (2) the costs are not significant. A delay on the part of domestic producers to expand would result in foreign companies increasing their production, leading to greater importation by the U.S.

9.2.4 Baseline Parameters

9.2.4.1 Model Plant Parameters. In order to evaluate the impacts of the proposed standard on each of the three markets, it is helpful to develop models of typical facilities in the magnetic tape industry and evaluate the impact on them. The model plants incorporate representative characteristics of expected new lines. Although there are three distinct markets in the magnetic tape industry, the manufacturing process is the same for audio, video, and computer recording media products and one coating line can be used to produce all types of tape products. However, there are differences in the sizes of coating lines that are used in the industry. In addition, the cost of manufacturing audio, video, and computer recording media products does vary with the product because of differences in raw material costs and costs of quality control procedures. These differences in costs are discussed in the following section.

Three model line sizes (research, small, and typical) have been selected to characterize the small and typical manufacturing lines and the research coating operations expected to be constructed in the near future. Production costs are given in Table 9-14. Further details of the model plants are provided in Chapter 6.

In actuality, plants produce various combinations of magnetic tape products. For example, some plants manufacture all three products (audio, video, and computer recording media) while others manufacture different types of computer recording media products (i.e., reel tape, flexible disks, etc.). Clearly it is not possible to develop models for all possible combinations. Therefore, to simplify the analysis, three model lines are used, and it is assumed that each line produces a different product (audio tape, video tape, and flexible disks).

Each product line is also specified by size (small and typical). The research line is not included in the analysis because it is used for experimental purposes rather than for the production of marketable products. It can be expected that because the additional costs necessitated by the NSPS for a research line are relatively small, they will be absorbed by the company. Therefore, a total of six model plants are included in the analysis (i.e., small and typical lines for each of the three products).

9.2.4.2 Cost Estimation. In order to measure the impacts of the standard on the model lines it is necessary to determine the preregulation as well as the post regulation costs on a model line basis. The cost figure used represents the cost of the coated tape at the completion of the coating process. Further processing of the tape into finished products (i.e., cassettes, reel tapes, flexible disks, etc.) requires additional manufacturing, marketing, and administrative costs. These costs do not affect the baseline process so the cost figure used represents only the value of the intermediate product at the end of the coating line.

It was very difficult to obtain financial information from manufacturing facilities because of the secretive nature of the industry. However, estimates of the cost per square meter to produce good quality audio tape were obtained from industry sources and averaged in order to present one representative cost figure.

TABLE 9-14. PREREGULATION PRODUCTION COSTS FOR MAGNETIC TAPE FACILITIES BY SIZE OF PRODUCTION LINE

	Audio tape		Video tape		Computer recording media	
	Small line[a]	Typical line[b]	Small line[a]	Typical line[b]	Small line[a]	Typical line[b]
Annual output of coated tape[c]						
m^2	3,483,750	34,837,500	3,483,750	34,837,500	3,483,750	34,837,500
ft^2	37,500,000	375,000,000	37,500,000	375,000,000	37,500,000	375,000,000
Cost[d]						
$\$/m^2$	0.452	0.452	2.26	2.26	4.52	4.52
$\$/ft^2$	0.042	0.042	0.21	0.21	0.42	0.42
Total costs,[e] $	1,575,000	15,750,000	7,875,000	78,750,000	15,750,000	157,500,000

[a] Production specification for small line: 6-inch wide tape, 250 feet per minute, 6,000 hours per year.

[b] Production specification for typical line: 26-inch wide tape, 500 feet per minute, 6,000 hours per year.

[c] It is assumed that 1/2-in. of film on both sides is discarded. For example, five inches rather than six is used for the tape width on the small line.

[d] Cost information from confidential industry sources.

[e] Differences in computed values are due to rounding. The actual values are shown in the table.

The preregulation cost per square foot to produce coated tape are shown in Table 9-14. Video and computer tapes are more expensive to produce than audio tape because of higher raw material costs and more stringent quality control standards. Confidential industry sources estimate that the cost to produce video tape is about five times that of audio tape and the cost to produce computer recording media is about twice that of video tape.

The cost per square foot is then multiplied by the coating line output. Assuming that 1.3 cm (1/2 in.) of film on both sides is discarded, then for example, 12.7 cm (five in.) rather than 15.2 cm (six in.) is used for tape width on the small line. These baseline parameters are shown in Table 9-14.

9.2.5 Selection of Regulatory Alternatives

The regulatory alternatives presented in Chapter 6 provide for increasing levels of control for the coating and mix room areas. Alternatives II and III control only the mix room while the remaining alternatives control either the coating operation alone or the coating and mix room. The regulatory alternatives are summarized in Table 9-15. All regulatory alternatives include the same level of control of emissions from the solvent storage tanks except for the baseline alternatives (I and IV). Although 14 alternatives are presented, in effect many more options would have to be evaluated if all of the control device options for each alternative were included in the analysis. For example, for Regulatory Alternative VIII, four possible control technologies can be used for the typical plant: fixed-bed carbon adsorbers; fluidized-bed carbon adsorbers; condensation system (solvent blend); and condensation system (cyclohexanone only). For several other regulatory alternatives there are also multiple options. Rather than examining all the options, only the common fixed-bed carbon adsorber is evaluated for those alternatives where multiple options exist because it is the system most often used and the general applicability of condensation systems is uncertain. It should also be noted that the compliance costs do not vary with the type of tape produced because the manufacturing process is the same for each product. The compliance costs vary with the level of pollution control, the type of control device, and the size of the coating line.

The volatile organic compound (VOC) regulations in States with magnetic tape coating facilities vary from requiring no control in ozone attainment areas to a required level of control in nonattainment areas for ozone. Therefore, two baseline levels for the coating operation are provided: Regulatory Alternative I provides for no controls and Alternative IV provides the necessary controls to meet the VOC requirement in ozone nonattainment areas. Most facilities in the industry are known to have installed at least the level of control associated with Baseline Alternative IV because the control devices offer the added benefit of recovering solvents. Therefore, because of the economic incentive of recovering solvents for reuse, most new facilities could be expected to install control devices as well.

TABLE 9-15. REGULATORY ALTERNATIVES AND CONTROL DEVICE CONFIGURATIONS

Reg Alt.	Emission capture			Control device		Overall VOC control, %
		Coating operation				
	Mix room	Flashoff	Oven	Mix room	Coating operation	
I (Baseline)	None	None	None	None	None	0
II	Covered/vented	None	None	Breather valve	None	4
III	Covered/vented	None	None	Carbon adsorber	None	9
IV (Baseline)	None	None	Yes	None	Carbon adsorber or condensation system	75
V	None	Partial encl.	Yes	None	Carbon adsorber or condensation system	78
VI	Covered/vented	None	Yes	Breather valve	Carbon adsorber or condensation system	79
VII	Covered/vented	Partial encl.	Yes	Breather valve	Carbon adsorber or condensation system	82
VIII	None	Total encl.	Yes	None	Carbon adsorber or condensation system	83
IX	Covered/vented	None	Yes	Carbon adsorber	Carbon adsorber or condensation system	84
X	None	Total encl.	Yes	None	Incinerator	85
XIA	Covered/vented	Total encl.	Yes	Breather valve	Carbon adsorber or condensation system	87
XIB	Covered/vented	Partial encl.	Yes	Carbon adsorber	Carbon adsorber or condensation system	87
XII	Covered/vented	Total encl.	Yes	Breather valve	Incinerator	89
XIII	Covered/vented	Total encl.	Yes	Carbon adsorber	Carbon adsorber or condensation system	92
XIV	Covered/vented	Total encl.	Yes	Carbon adsorber	Incinerator	94

Therefore, the baseline level of control used in the analysis is Regulatory Alternative IV. However, for the regulatory alternatives that control only the mix room and solvent storage tanks (II and III) the baseline used for comparison is Regulatory Alternative I (no control).

Tables 9-16 and 9-17 provide the total capital and total annualized control costs and the incremental capital and annualized control costs for each regulatory alternative for the small and typical model plants. The incremental cost is the difference between each regulatory alternative and the baseline. (See Tables 8-14 and 8-15 for baseline costs). For some regulatory alternatives the incremental cost of moving to higher levels of control may be negative, reflecting the existence of lower annualized costs for those alternatives which remove a larger proportion of the pollutant than that represented by the baseline. Where such negative incremental costs do occur in the tables they can be attributed to the increased profits from the recovery of solvents which in turn reduce the total and annualized costs. For those cases where the annualized control costs are less than the baseline, the incremental costs are assumed to be zero even though costs could have decreased.

9.2.6 Economic Impact Estimates

Compliance costs will either be passed forward or absorbed by the industry depending upon market conditions. The percentage change of the cost increase is computed by dividing the incremental annualized costs of each regulatory alternative by the pre-NSPS total costs for each model line size. These pre-NSPS costs are shown in Table 9-14. The incremental cost is the difference between the annualized cost of each regulatory alternative and the baseline annualized costs. This computation permits an analysis of the impact of each regulatory alternative compared to the present level of control. The result represents the percentage changes in cost caused by the various regulatory alternatives. Table 9-18 presents the results of the cost increase calculations for the three product types.

The cost analysis can be carried one step further by examining the impact on retail prices. This analysis shows the effects of the standards, if any, on the consumer prices of magnetic tape products. The maximum consumer impact can be calculated by using the largest cost increase for each product and computing the impact on the retail prices shown in Table 9-11. The results of these calculations are shown in Tables 9-19 through 9-21. For example, the largest cost increase for flexible disks is 0.27 percent. Therefore, the increase in cost per square meter of coated tape is \$4.52 (cost to produce flexible disks) x 0.27 percent, or \$0.026. Using a single-sided 13.3-cm (5-1/4 in.) flexible disk as the representative product, there are 0.0139 m^2 of tape per unit. The total increase in cost for the flexible disk is 0.0139 x \$0.026, or \$0.00017. This amount is added to the high retail price of the disk to arrive at the post control retail price of \$3.38, as shown in Table 9-21. The following three sections discuss the

TABLE 9-16. TOTAL AND INCREMENTAL CAPITAL AND ANNUALIZED COSTS ASSOCIATED WITH THE COATING OPERATION, MIX ROOM, AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES FOR SMALL MODEL PLANTS

Regulatory alternatives	Capital costs			Annualized costs		
	Total costs	Incremental baseline A	Incremental baseline B	Total costs	Incremental baseline A	Incremental baseline B
I (Baseline A)	$1,304,900	$ 0		$1,728,900	$ 0	
II	1,310,000	5,100		1,727,800	-1,100	
III	1,342,500	37,600		1,751,900	23,000	
IV (Baseline B)	1,436,500		$ 0	1,777,000		$ 0
V	1,445,200		8,700	1,779,100		2,100
VI	1,441,600		5,100	1,775,800		-1,200
VII	1,449,300		12,800	1,777,700		700
VIII	1,453,600		17,100	1,781,800		4,800
IX	1,442,200		5,700	1,779,200		2,200
X	1,534,600		98,100	1,796,600		19,600
XIA	1,457,700		21,200	1,780,400		3,400
XIB	1,449,900		13,400	1,781,100		4,100
XII	1,538,700		102,200	1,795,200		18,200
XIII	1,458,300		21,800	1,783,800		6,800
XIV	1,571,200		134,700	1,819,400		42,400

TABLE 9-17. TOTAL AND INCREMENTAL CAPITAL AND ANNUALIZED COSTS ASSOCIATED WITH THE COATING OPERATION, MIX ROOM, AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES FOR TYPICAL MODEL PLANTS

	Capital costs			Annualized costs		
Regulatory alternatives	Total costs	Incremental baseline A	Incremental baseline B	Total costs	Incremental baseline A	Incremental baseline B
I (Baseline A)	$3,067,500	$ 0		$11,125,800	$ 0	
II	3,072,600	5,100		11,105,700	-20,100	
III	3,105,100	37,600		11,156,100	30,300	
IV (Baseline B)	4,647,500		$ 0	11,177,800		$ 0
V	4,667,500		20,000	11,166,500		-20,700
VI	4,652,600		5,100	11,157,100		-20,700
VII	4,672,600		25,100	11,145,900		-31,900
VIII	4,675,700		28,200	11,144,800		-33,000
IX	4,653,200		5,700	11,138,200		-39,600
X	3,368,800		-1,278,700	11,279,400		101,600
XIA	4,679,800		32,300	11,149,500		-28,300
XIB	4,673,200		25,700	11,127,000		-50,800
XII	3,372,900		-1,274,600	11,258,600		80,800
XIII	4,680,400		32,900	11,105,100		-72,700
XIV	3,405,400		-1,242,100	11,309,500		131,700

significance of the cost and retail price increases for each of the three magnetic tape markets as well as other market impacts.

9.2.6.1 Audio Tape Market. Little growth is anticipated in the audio tape market. No new lines or plants are expected to be built in this market during the next 5 years. The NSPS will not affect production and consumption of audio tape products or increase retail prices; the cost increases shown in Table 9-18 and retail price increases shown in Table 9-19 would occur only if new facilities were built. These small increases would have little effect, as they would most likely be absorbed by the industry.

9.2.6.2 Video Tape Market. As a result of the NSPS, new facilities will be faced with the cost increases shown in Table 9-18. If the plants pass forward the costs of the NSPS, then consumers will pay slightly more for a video cassette, as shown in Table 9-20. However, due to the great number of foreign firms in the video tape market, it is unlikely that the costs can be passed forward. More likely they will be absorbed by the industry. Since the production cost increases range from 0 to 0.54 percent and since there are at present variations in costs among the firms in the industry, the NSPS should not cause greater differences in the cost structure than those that already exist between established and new firms or between domestic and foreign firms. In other words, the existing differences in cost structures will not widen. An additional 21 new production lines for video and computer recording media products are expected over the next 5 years. This forecast should not change as a result of the NSPS because the impacts are very small. Nor will the NSPS cause a change in production or consumption of video tape products.

9.2.6.3 Computer Recording Media Market. Since foreign competition does not play as prominent a role in this market, it can be expected that initially cost increases will be passed forward completely as argued above in Section 9.2.3.3. A 0.27 percent increase in manufacturing costs for coated tape will probably have no effect on retail prices, as shown in Table 9-21. The NSPS will have no effect on the expansion plans of these firms. An additional 21 production lines for video and computer recording media products are forecasted over the next 5 years. However, by the mid-or-late 1980's, Japanese competition will become significant in the flexible disk market. At that time the U.S. industry will either have to absorb the compliance costs or delay their expansion plans. The industry is not likely to choose the second option because it would result in loss of market share. Maintaining or increasing market share is crucial in this highly competitive industry. The industry can be expected to absorb the costs, which will have little impact because the costs are relatively small. There will also be little impact on the production or consumption of computer recording media products.

9.2.7 Capital Availability

The remaining issue to be discussed is the manufacturers' ability to raise capital in order to purchase the necessary pollution control

TABLE 9-18. MAXIMUM PERCENT COST INCREASES FOR THE MANUFACTURERS OF COATED WEB ASSOCIATED WITH THE COATING OPERATION, MIX ROOM, AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES[a]

Regulatory alternatives	Audio tape		Video tape		Computer recording media	
	Small (percent)	Typical (percent)	Small (percent)	Typical (percent)	Small (percent)	Typical (percent)
II	0	0	0	0	0	0
III	1.46	0.19	0.29	0.04	0.15	0.02
V	0.13	0	0.03	0	0.01	0
VI	0	0	0	0	0	0
VII	0.04	0	0.01	0	0.004	0
VIII	0.30	0	0.06	0	0.03	0
IX	0.14	0	0.03	0	0.01	0
X	1.24	0.65	0.25	0.13	0.12	0.06
XIA	0.22	0	0.04	0	0.02	0
XIB	0.26	0	0.05	0	0.03	0
XII	1.16	0.51	0.23	0.10	0.12	0.05
XIII	0.43	0	0.09	0	0.04	0
XIV	2.69	0.84	0.54	0.17	0.27	0.08

[a] These calculations are based on the assumption that all of the costs are passed forward, hence they represent the maximum percent cost increase. These cost increases reflect the coating process only, not the finishing process of converting the tape into final products.

TABLE 9-19. RETAIL PRICE INCREASES FOR AUDIO TAPE PRODUCTS FOR THE COATING OPERATION, MIX ROOM, AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES

	Open reel		Cassette	
	18-cm (7-in.) plastic reel 366m (1,200 ft)		90 minute	
	Low price	High price	Low price	High price
Cost/m^2	\$0.452	\$0.452	\$0.452	\$0.452
(Cost/ft^2)	(\$0.042)	(\$0.042)	(\$0.042)	(\$0.042)
Highest cost increase	2.69%	2.69%	2.69%	2.69%
Retail price (price range/unit) [54-56]	\$5.85	\$6.75	\$1.52	\$4.39
m^2 of tape/unit	2.32	2.32	0.51	0.51
(ft^2 of tape/unit)	(24.96)	(24.96)	(5.5)	(5.5)
Increase in price[a,b] (m^2)	\$0.012	\$0.012	\$0.012	\$0.012
(Increase in price) (ft^2)	(\$0.00113)	(\$0.00113)	(\$0.00113)	(\$0.00113)
Increase in price[c] (unit)	\$0.028	\$0.028	\$0.006	\$0.006
New retail price (Including cost increase)	\$5.88	\$6.78	\$1.53	\$4.40
Percent increase in price	0.5	0.4	0.7	0.2

[a] The increase in price (m^2) is the same for all products because the highest cost increase for all products represents the same Regulatory Alternative XIV.

[b] Increase in price (m^2) = Highest cost increase x Cost/m^2.

[c] Increase in price (unit) = Increase in price (m^2) x m^2 of tape/unit.

TABLE 9-20. RETAIL PRICE INCREASES FOR VIDEO TAPE PRODUCTS FOR THE COATING OPERATION, MIX ROOM AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES

	4 hr. VHS cassette		6 hr. VHS cassette	
	Low price	High price	Low price	High price
Cost/m^2	\$2.26	\$2.26	\$2.26	\$2.26
(Cost/ft^2)	(\$0.21)	(\$0.21)	(\$0.21)	(\$0.21)
Highest cost increase	0.54%	0.54%	0.54%	0.54%
Retail price (price range/unit) [54-56]	\$9.69	\$14.85	\$8.17	\$11.92
m^2 of tape/unit	3.058	3.058	1.51	1.51
(ft^2 of tape/unit)	(32.92)	(32.92)	(16.25)	(16.25)
Increase in price[a,b] (m^2)	\$0.012	\$0.012	\$0.012	\$0.012
(Increase in price) (ft^2)	(\$0.00113)	(\$0.00113)	(\$0.00113)	(\$0.00113)
Increase in price[c] (unit)	\$0.037	\$0.037	\$0.018	\$0.018
New retail price (Including cost increase)	\$9.73	\$14.89	\$8.19	\$11.94
Percent increase in price	0.4	0.3	0.2	0.2

[a] The increase in price (m^2) is the same for all products because the highest cost increase for all products represents the same Regulatory Alternative XIV.

[b] Increase in price (m^2) = Highest cost increase x Cost/m^2.

[c] Increase in price (unit) = Increase in price (m^2) x m^2 of tape/unit.

TABLE 9-21. RETAIL PRICE INCREASES FOR COMPUTER RECORDING MEDIA PRODUCTS FOR THE COATING OPERATION, MIX ROOM AND SOLVENT STORAGE TANK REGULATORY ALTERNATIVES

	Flexible Disks				
	13.3-cm (5-1/4-in.) single-sided		13.3-cm (5-1/4-in.) double-sided		Data Cassette
	Low price	High price	Low price	High price	90 minutes
Cost/m^2	\$4.52	\$4.52	\$4.52	\$4.52	\$4.52
(Cost/ft^2)	(\$0.42)	(\$0.42)	(\$0.42)	(\$0.42)	(\$0.42)
Highest cost increase	0.27%	0.27%	0.27%	0.27%	0.27%
Retail price (price range/unit) [54-56]	\$2.60	\$3.38	\$3.70	\$4.20	\$3.93
m^2 of tape/unit	0.014	0.014	0.014	0.014	0.31
(ft^2 of tape/unit)	(0.15)	(0.15)	(0.15)	(0.15)	(3.38)
Increase in price[a,b] (m^2)	\$0.012	\$0.012	\$0.012	\$0.012	\$0.012
(Increase in price) (ft^2)	(\$0.00113)	(\$0.00113)	(\$0.00113)	(\$0.00113)	(\$0.00113)
Increase in price[c] (unit)	\$0.00017	\$0.00017	\$0.00017	\$0.00017	\$0.004
New retail price (Including cost increase)	\$2.60	\$3.38	\$3.70	\$4.20	\$3.93
Percent increase in price	0.0	0.0	0.0	0.0	0.0

[a] The increase in price (m^2) is the same for all products because the highest cost increase for all products represents the same Regulatory Alternative XIV.

[b] Increase in price (m^2) = Highest cost increase x Cost/m^2.

[c] Increase in price (unit) = Increase in price (m^2) x m^2 of tape/unit. (The numbers used in this calculation are rounded. However, the actual results are shown in the table.)

equipment. Debt financing is usually the preferred method to finance pollution control equipment, so it is helpful to look at the industry's current levels of debt in comparison with the capital costs of the NSPS.

Many of the companies in the industry are large, multinational companies such as IBM, BASF, Memorex, Sony, 3M, and others. These companies each have a minimum of several hundred million dollars of long-term debt. Even the most costly regulatory alternative, approximately $368,000 per company, as shown in Table 9-16 would not increase these companies' debt by more than one percent each. Also, medium-sized companies, such as Dysan, Xidex, Verbatim, and Certron Corp., are not likely to experience serious capital availability problems.

9.3 SOCIO-ECONOMIC IMPACT ASSESSMENT

The previous section has described how the magnetic tape producing segment of the national economy might be affected by the NSPS. In this section the scope of the analysis is expanded so that the probability of broader economic effects might be assessed. Among the issues examined are those related to employment, regional effects, and the potential for adverse impacts upon small businesses.

9.3.1 Executive Order 12291

This section addresses those tests of macroeconomic impact presented in Executive Order 12291 to determine whether or not a detailed regulatory analysis is required; that is, whether this regulation can be expected to produce any of the following impacts:

1. An annual effect on the economy of $100 million or more as measured by the fifth year annualized control cost;

2. A major increase in costs or prices for consumers; individual industries; Federal, State, or local government agencies; or geographic regions; and

3. Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of U.S.-based enterprises to compete with foreign-based enterprises in domestic or export markets.

9.3.1.1 Fifth Year Annualized Control Costs. It is projected that there will be 21 new lines constructed during the next 5 years for the manufacture of video and computer recording media products. Assuming that the most costly regulatory alternative is chosen, the total fifth year annualized costs are approximately $2.2 million. Clearly this figure is well below the $100 million level.

9.3.1.2 Price Increases. As calculated in Section 9.2.6, no major cost or price increases will result from the standard. The largest cost increase associated with the greatest level of control is 0.54 percent for the manufacture of video tape which would cause a 0.4 percent retail that the most costly regulatory alternative is chosen, the total fifth year annualized costs are approximately $2.2 million. Clearly this figure is well below the $100 million level.

9.3.1.2 Price Increases. As calculated in Section 9.2.6, no major cost or price increases will result from the standard. The largest cost increase associated with the greatest level of control is 0.54 percent for the manufacture of video tape which would cause a 0.4 percent retail price increase at most. There will be no effect of the standard on audio tape prices.

9.3.1.3 Regional Effects, Employment and Productivity. The 29 facilities of the magnetic tape industry are located in 15 States, with 34 percent of the industry in California. No adverse impacts are expected in any State as a result of the regulation. Also, the minimal impacts of the standard are not expected to effect employment levels or productivity in the industry.

9.3.2 Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (RFA) requires that the economic impact assessment determine whether the regulation is likely to have a significant impact on small businesses and whether a substantial number of small businesses will experience significant impacts. Both measures must be met to require an analysis; that is, there must be both significant impact and a substantial number of small businesses. If either measure is not met, then no analysis is required. The EPA defines a "substantial number" of small businesses in an industry as 20 percent of the total number of firms in the industry, and defines "significant impact" as meeting at least one of these three tests: 1) prices for small entities rise 5 percent or more, assuming costs are not passed onto consumers; (2) annualized investment costs for pollution control are greater than 20 percent of total capital spending; or (3) costs as a percent of sales for small firms are ten percent greater than costs as a percent of sales for large firms.

The Small Business Administration (SBA) definition of a small business for SIC codes 3573 and 3679 is a firm that employs 500 persons or less. Of the 23 companies in the magnetic tape industry, 17 can be considered medium or large businesses. The other 6 are privately owned and little information is available concerning their operations, but five of them could possibly be considered small businesses. It should be noted that the distinction between large and small plants or firms is likely to be related to the number of lines in the facility, not the size of the lines. A small plant may have a large line while a large plant could have several small lines. Therefore, a small firm that has a large line may be able to take advantage of the lower costs of controls that are associated with some of the regulatory alternatives for the larger line.

Growth in the industry is expected to take the form of existing companies adding additional lines as opposed to new companies entering the industry. The economic impact analysis (Section 9.2) has shown that there will be minimal adverse impacts on the existing companies in the magnetic tape industry as a result of the NSPS. If new (i.e., small) companies enter the industry it is likely that they will be affected by the NSPS to a greater degree than larger companies, because of the greater relative capital requirements and the higher control costs per unit of product for a small company. However, a significant impact is not anticipated.

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APPENDIX A--EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

APPENDIX A
EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

The purpose of this study was to develop a basis for supporting proposed new source performance standards (NSPS) for the magnetic tape coating industry. To accomplish the objectives of this program technical data were acquired on the following aspects of the magnetic tape coating industry: (1) solvent storage tanks, mix preparation equipment, and coating operations; (2) the release and controllability of organic emissions into the atmosphere by these sources; and (3) the types and costs of demonstrated emission control technologies. The bulk of the information was gathered from the following sources:

- Open technical literature
- Canvassing of State, regional, and local air pollution control agencies
- Plant visits
- Meetings with industry representatives
- Contact with engineering consultants and equipment vendors
- Emission source testing data

Significant events relating to the evolution of the BID are itemized in Table A-1.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Date	Company, consultant, or agency/location	Nature of action
9/24/81	IBM Corp. Boulder, Colo.	Plant visit
10/28/81	Memorex Company Santa Clara, Calif.	Plant visit
11/6/81	3M Company (St. Paul, Minn.), U.S. EPA, and Development, Planning, and Research Associates, Inc.	Meeting to discuss magnetic tape production and pollution control technology
11/19/81	Sony Magnetic Products, Inc. Dothan, Ala.	Meeting to discuss proposed plant visit
12/16/81	Sony Magnetic Products, Inc. Dothan, Ala.	Plant visit
2/19/82	Tandy Magnetic Forth Worth, Tex.	Plant visit
3/26/82	Capitol Magnetic Products Glenbrook, Conn.	Plant visit
7/30/82	Plant No. 2	Emission test
8/19/82	Plant No. 3	Emission test
11/16/82	Midwest Research Institute Raleigh, N.C.	Project start date for new contractor
1/10/83	U.S. EPA	Memo authorizing Phase II - "Draft Development of New Source Performance Standards for Magnetic Tape Coating Industry"
1/27/83	Columbia Magnetic Products Carrollton, Ga.	Plant visit
1/28/83	Ampex Opelika, Ala.	Plant visit

(continued)

TABLE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
3/18/83	American Video Tape Gardena, Calif.	Section 114 information request
	BASF Systems Corp. Bedford, Mass.	
	Certron Corp. Anaheim, Calif.	
	IBM Corp. Tucson, Ariz.	
	3M Company St. Paul, Minn.	
	Sony Dothan, Ala.	
	Spectrotape Loma Linda, Calif.	
	Syncom Mitchell, S.D.	
	Verbatim Corp. Sunnyvale, Calif.	
8/3/83	Precision Media Sunnyvale, Calif.	Request for information
8/5/83	BASF Systems Corp. Bedford, Mass.	Plant visit
9/13/83	Mailed to industry members, selected equipment vendors, and consultants	Request for comment on draft BID Chapters 3, 4, 5, and 6
11/14/83	Spectrotape Loma Linda, Calif.	Follow-up to Section 114 information request
11/21/83	American Video Tape Gardena, Calif.	Follow-up to Section 114 information request

(continued)

TABE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
11/21/83	Precision Media Sunnyvale, Calif.	Follow-up to request for information
4/26/84	IBM Corp. Boulder, Colo.	Section 114 information request: mix rooms and solvent storage tanks
	Graham Magnetics Graham, Tex.	
	Capitol Magnetic Products Glenbrook, Conn.	
	Tandy Magnetic Media Company Santa Clara, Calif.	
	Opus Computer Resources Cleveland, Ohio	
6/29/84	3M Company Camarillo, Calif.	Plant visit
7/2/84	Memorex Company Santa Clara, Calif.	Plant visit
7/2/84	Mailed to members of the Working Group	Working Group mailout
8/2/84	Columbia Magnetic Products Carrollton, Ga.	Plant visit
8/29/84	U. S. EPA and industry representatives	NAPCTAC Meeting
11/84	Mailed to members of Steering Committee	Steering Committee mailout
3/85	Mailed to members of Red Border review	Red Border review

APPENDIX B--INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

APPENDIX B
INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system which is cross-indexed with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of environmental impact statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

TABLE B-1. CROSS-INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
1. BACKGROUND AND SUMMARY OF REGULATORY ALTERNATIVES	
Summary of regulatory alternatives	The regulatory alternatives from which standards will be chosen for proposal are summarized in Chapter 1, Section 1.1.
Statutory basis for proposing standards	The statutory basis for proposing standards is summarized in Chapter 2, Section 2.1.
Relationship to other regulatory agency actions	The relationships between EPA and other regulatory agency actions are discussed in Chapter 3.
Industry affected by the regulatory alternatives	A discussion of the industry affected by the regulatory alternatives is presented in Chapter 3, Section 3.1. Further details covering the business and economic nature of the industry are presented in Chapter 9, Section 9.1.
Specific processes affected by the regulatory alternatives	The specific processes and facilities affected by the regulatory alternatives are summarized in Chapter 1, Section 1.1. A detailed technical discussion of the processes affected by the regulatory alternatives is presented in Chapter 3, Section 3.2.
2. REGULATORY ALTERNATIVES	
Control techniques	The alternative control techniques are discussed in Chapter 4.

(continued)

TABLE B-1. (continued)

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
Regulatory alternatives	The various regulatory alternatives are defined in Chapter 6, Section 6.4. A summary of the major alternatives considered is included in Chapter 1, Section 1.1.
3. ENVIRONMENTAL IMPACT OF THE REGULATORY ALTERNATIVES	
Primary impacts directly attributable to the regulatory alternatives	The primary impacts on mass emissions and ambient air quality due to the alternative control systems are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5. A matrix summarizing the environmental impacts is included in Chapter 1.
Secondary or induced impacts	Secondary impacts for the various regulatory alternatives are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5.
4. OTHER CONSIDERATIONS	A summary of the potential adverse environmental impacts associated with the regulatory alternatives is included in Chapter 1, Section 1.2, and Chapter 7. Potential socio-economic and inflationary impacts are discussed in Chapter 9, Section 9.2. Irreversible and irretrievable commitments of resources are discussed in Chapter 7, Section 7.6.

APPENDIX C--EMISSION SOURCE TEST DATA

APPENDIX C
Emission Source Test Data

The emission source test data presented here were obtained from (1) EPA-sponsored testing, (2) magnetic tape industry data on carbon adsorbers, (3) State compliance tests, and (4) EPA-sponsored testing for a related industry. The following sections discuss these data.

C.1 DATA FROM EPA-SPONSORED TESTS ON CARBON ADSORBER RECOVERY EFFICIENCIES

Tests were conducted at two magnetic tape coating plants to determine the solvent recovery efficiencies of the fixed-bed carbon adsorbers. At Plant 2, the carbon adsorption system recovers a mixture of toluene and tetrahydrofuran (THF) solvent from the tape coating process. The system features three annular carbon beds and processes 4.6 normal cubic meters per second (Nm^3/s) (9,800 standard cubic feet per minute [scfm]) of solvent-laden air (SLA). The three beds repetitively undergo adsorption and desorption in a staggered sequence that is controlled by a timer. The adsorption period is set at 64 minutes per bed, and desorption is set at 32 minutes per bed. The cycle does not include a bed cooldown period after the desorption period. A continuous distillation train separates solvent that is removed from the beds during steam desorption into toluene-and THF-rich fractions.

During the 3-week test period, a hydrocarbon analyzer semicontinuously monitored the inlet and outlet solvent concentrations. The analyzer data were digitized and input to an onsite computerized data acquisition system. Table C-1 presents the operating conditions encountered during the tests. Table C-2 presents a summary of the results of the tests. The inlet toluene/THF concentration averaged 1,230 parts per million by volume (ppmv), which corresponds to an inlet solvent mass rate of 70.5 kilograms per hour (kg/h) (156 pounds per hour [lb/h]). Inlet concentrations varied from about 50 to over 2,400 ppmv, depending on the number of operating coating lines, the coating speed, and the coating thickness. The time-averaged outlet concentrations from Beds 1, 2, and 3 were 5.2, 2.2, and 2.4 ppmv, respectively, which correspond to outlet solvent mass rates of 0.15, 0.071, and 0.078 kg/h (0.33, 0.16, and 0.17 lb/h), respectively. Therefore, average system volatile organic compound (VOC) removal efficiencies were 99.8, 99.9, and 99.9 percent for Beds 1, 2, and 3, respectively, based on solvent mass rates. Outlet solvent concentrations varied from near 0 to over 100 ppmv, depending primarily upon cycle timing. Laboratory analysis indicated that bed carbon adsorption capacity was significantly below virgin carbon capacity levels. However, the reduced adsorption capacity apparently did not severely affect system performance, as indicated by the bed VOC removal levels approaching 100 percent.

Plant 3 manufactures magnetic tape by coating a polyester film or web with ground magnetic iron oxide slurried with a solvent formulation of primarily THF and toluene with small amounts of methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and cyclohexanone. The carbon adsorption system recovers the solvent driven off during the coating process. The system, which has been operational since 1978, processes 9.4 Nm^3/s (19,800 scfm) of SLA. The system features three pairs of annular carbon beds, with two pairs on-line and one pair maintained as a spare. The two on-line pairs operate on a 90-minute timed adsorption/regeneration cycle. The system processes SLA with an approximate inlet solvent concentration of 2,000 or 5,000 ppmv, depending on the type of magnetic tape being produced. The system is regenerated by low-pressure steam desorption and ambient air cooldown. A batch distillation train separates solvent that is removed from the beds during steam desorption into component fractions.

During the 2-week test period, hydrocarbon analyzers semicontinuously monitored the inlet and outlet solvent concentrations. The analyzer data were digitized and input to an onsite computerized data acquisition system. Table C-3 presents a summary of the operating parameters encountered during the tests. Table C-4 presents a summary of the results of the VOC sampling. The data show VOC removal efficiencies ranging from 91 to 98 percent. The measured VOC removal efficiency for each bed was generally based on an average of 10 cycles of adsorption and regeneration. The carbon in Beds 3A and 3B had been in service for only 1 to 2 weeks at the time of the testing. These beds had substantially better VOC reduction performance than did Beds 1A, 1B, and 2A, which all contained carbon with up to 5 months of service.

C.2 DATA FROM INDUSTRY ON CARBON ADSORBER RECOVERY EFFICIENCIES

A two-bed fixed-bed carbon adsorption system installed in 1980 controls the VOC emissions from the magnetic tape coating operation at the IBM Corporation facility in Tucson, Arizona. Table C-5 presents a summary of the normal operating parameters of this system. Table C-6 presents a summary of the monthly average VOC control efficiencies for 1982. Control efficiencies ranged from 94 to 99 percent.

The 3M Company facility in Camarillo, California, coats computer tape and disks. Two separate fixed-bed carbon adsorbers, one with four beds and one with two beds, control VOC emissions. The systems were installed in 1975 and 1979. Table C-7 presents the actual operating parameters of these systems. Table C-8 presents a summary of the monthly average control device efficiencies for a 12-month period. Monthly average control efficiencies ranged from 89 to 97 percent.

C.3 DATA FROM STATE COMPLIANCE TESTS

The Allied Media Technology facility in Sunnyvale, California, operated two coating lines that produced video and computer tape products. A nitrogen condensation system controlled oven VOC emissions. The control device recovery efficiency was determined by conducting a 3-hour liquid solvent material balance on February 25, 1983. The amount of solvent applied was calculated from the operating parameters of both lines. Table C-9 presents a summary of these data. The total amount of solvent applied during the test period was 110.2 kg (242.9 lb). The amount of solvent recovered was calculated from the weight of the solvent drum after collection, minus the weight of the drum and the weight of the solvent in the drum before collection during the test. These data are presented in Table C-10. The total amount of solvent recovered during the test was 102.5 kg (226.0 lb). The solvent recovery efficiency of this coating operation VOC control system was 93.0 percent (102.5 kg ÷ 110.2 kg) (226.0 lb ÷ 243.0 lb).

C.4 DATA FROM EPA-SPONSORED TESTS FOR RELATED INDUSTRIES

The EPA conducted tests at plants in the pressure-sensitive tape and label (PSTL) industry. This is an industry with coating and control processes very similar to those used in the magnetic tape manufacturing industry. In both industries, a solvent-based coating is applied to a continuous supporting web. Fixed-bed carbon adsorbers are the most commonly used control device in both industries, and similar total enclosures around the coating application/flashoff area are used to capture fugitive VOC emissions. The following paragraphs describe relevant test data from the PSTL industry.

One PSTL facility was examined over a 4-week period (January 15, 1979, to February 9, 1979). The facility consists of four adhesive coating lines controlled by a single carbon adsorption system. There are three lines that are each 71-centimeters (cm) (28-inches) wide, and one line that is 144-cm (56-inches) wide. The plant operation is characterized by many short runs at slow line speeds. Table C-11 summarizes the operations of each line and the total system. This facility is an example of a hard to control facility because slow coating lines are the most difficult to control (e.g., they have the greatest potential for fugitive solvent emissions).

During the 4-week test period, the controlled facility used 28.7 m^3 (7,589 gallons) of solvents in its adhesive formulations and recovered 226.7 m^3 (7,065 gallons) from the carbon adsorption facility. This represents an overall VOC control of 93.1 percent. The system performed 140 separate runs and used the following solvents: toluene, acetone, hexane, ethyl acetate, MEK, rubber solvent, heptane, mixed solvents, recovered pro lam solvents, xylene, ethyl alcohol, and isopropanol.

The makeup air for the ovens is pulled directly from the work area. The building that houses the coaters is tight enough to allow a slight negative pressure in the work area as compared to the outside of the building. Also, there is a slight negative pressure in the coater ovens with respect to the room air. With a fully enclosed, tight system, the overall result is that all makeup air flows into the building, through the oven, and out to the carbon adsorption system. Therefore, essentially 100 percent of all solvent emissions are captured. The facility also uses hoods over the coater areas to capture fugitive solvent emissions near the coating applicator. Ductwork directs hood gases into the drying oven.

TABLE C-1. ADSORPTION MODE DATA--PLANT 2

Parameter	Average value	Range
Adsorption mode length	64 minutes	N/A[a]
Inlet SLA flow rate (common inlet)	4.6 Nm^3/s (9,800 scfm)	4.5-4.7 Nm^3/s (9,500-10,000 scfm)
Inlet SLA superficial velocity (through beds)	0.24 m/s (47 ft/min)	0.24-0.25 m^3/s (47-49 ft/min)
Inlet solvent concentration	1,230 ppmv as toluene and THF	48-2,420 ppmv as toluene and THF[b]
Inlet solvent loading	70.6 kg/h (156 lb/h)	2.8-139 kg/h (6.1-306 lb/h)
Inlet temperature (after air cooler)	23°C (74°F)	21-26°C (70-78°F)
Inlet relative humidity (after air cooler)	30%	15-60%
Air cooler temperature drop (process side)	9°C (17°F)	6-12°C (112°F)
Air cooler temperature rise (water side)	11°C (20°F)[c]	d
Air cooler water flow rate	d	d
Blower rating	45 kW (60 hp)	d
Bed 1 pressure drop	1.05 kPa (4.2 in. w.c.)	1.02-1.05 kPa 4.1-4.2 in. w.c.)
Bed 2 pressure drop	1.00 kPa (4.0 in. w.c.)	0.97-1.02 kPa (3.9-4.1 in. w.c.)
Bed 3 pressure drop	0.90 kPa (3.6 in. w.c.)	0.90-0.92 kPa (3.6-3.7 in. w.c.)

(continued)

TABLE C-1. (continued)

Parameter	Average value	Range
Bed 1 outlet flow rate	2.3 Nm^3/s (4,900 scfm)	2.3-2.4 Nm^3/s (4,800-5,000 scfm)
Bed 2 outlet flow rate	2.6 Nm^3/s (5,500 scfm)	2.5-2.6 Nm^3/s (5,300-5,600 scfm)
Bed 3 outlet flow rate	2.6 Nm^3/s (5,500 scfm)	2.5-2.6 Nm^3/s (5,300-5,600 scfm)
Bed 1 outlet solvent concentration	5.2 ppmv	1-113 ppmv as toluene and THF[b]
Bed 2 outlet solvent concentration	3.2 ppmv	0-53 ppmv as toluene and THF[b]
Bed 3 outlet solvent concentration	2.4 ppmv	0-22 ppmv as toluene and THF[b]
Bed 1 outlet solvent flow rate	0.15 kg/h (0.33 lb/h)	0.03-3.25 kg/h (0.07-7.17 lb/h
Bed 2 outlet solvent flow rate	0.071 kg/h (0.16 lb/h)	0-1.71 kg/h (0-3.77 lb/h)
Bed 3 outlet solvent flow rate	0.78 kg/h (0.17 lb/h)	0-0.71 kg/h (0-1.57 lb/h)
Outlet temperature	36°C (96°F)[e,f]	25-99°C (77-210°F)[e,f]
Outlet relative humidity	35%[e,f]	22-100%

[a] Not applicable.
[b] Assumes a 50/50 mole percent mixture of toluene and THF.
[c] Design value.
[d] Unknown.
[e] Estimated.
[f] Values include the portion of the adsorption mode required for bed cooling and drying (no distinct cooldown period).

TABLE C-2. SUMMARIZED CARBON ADSORBER VOC REMOVAL DATA--PLANT 2

Sample point	Average solvent[a] concentration, ppmv	Range of solvent[a] concentrations, ppmv	Average solvent mass rate, kg/h (lb/h)	Average bed removal efficiency, %
Inlet	1,230	48-2,420	70.5 (156)	N/A[b]
Bed 1 outlet	5.2	1-113	0.15 (0.33)	99.8
Bed 2 outlet	2.2	0-53	0.071 (0.16)	99.9
Bed 3 outlet	2.4	0-22	0.078 (0.17)	99.9

[a] Expressed as a 50/50 mole percent mixture of toluene and THF.
[b] Not applicable.

TABLE C-3. ADSORPTION MODE DATA--PLANT 3

Parameter	Average value	Range
Adsorption mode length	47 min	N/A[a]
Inlet SLA flow rate (all beds)[b]	9.33 Nm^3/s (19,780 scfm)	8.55-9.98 Nm^3/s (18,110-21,140 scfm)
Inlet SLA superficial velocity (through beds)	0.45 m/s (90 ft/min)	c
Bed 3A/3B outlet flow rate	4.08 Nm^3/s (8,650 scfm)	3.97-4.24 Nm^3/s (8,420-8,990 scfm)
Bed 2A/2B outlet flow rate	4.73 Nm^3/s (10,010 scfm)	4.62-4.74 Nm^3/s (9,780-10,050 scfm)
Bed 1A/1B outlet flow rate	NA[d]	c
Inlet gas temperature	27°C (81°F)	24-32°C (76-90°F)
Inlet gas relative humidity	30%	22-40%
Outlet gas temperature	26°C (78°F)	21-33°C (70-92°F)
Bed pressure drop 1A/1B	1.4 kPa (5.8 in. H_2O)	c
Bed pressure drop 2A/2B	1.3 kPa (5.4 in. H_2O)	c
Bed pressure drop 3A/3B	0.97 kPa (3.9 in. H_2O)	c

(continued)

TABLE C-3. (continued)

Parameter	Average value	Range
Air cooler temperature drop (water side)	11°C (20°F)	8-12°C (15-22°F)
Air cooler water flow rate[e]	30 m^3/h (130 gal/min)	c
SLA fan energy consumption[f] (total)	32.4 kW	c

[a] Not applicable.
[b] Flow rate calculated at one atmosphere.
[c] Unknown.
[d] Not available. Existing stacks were too short for accurate flow measurement. The other beds had stack extensions.
[e] Estimated from temperature drop.
[f] Determined by ammeter.

TABLE C-4. SUMMARY OF CARBON ADSORBER VOC REMOVAL DATA--PLANT 3

Outlet sampling location	Inlet concentration level	Average solvent concentrations, ppmv[a]			Average solvent mass flow rates, kg/h (lb/h)			Average bed, %
		Inlet	Outlet during adsorption	Outlet during cooldown	Inlet	Outlet during adsorption	Outlet during cooldown	
Bed 1A[b,d]	Low	2,295	107	447	148 (326)	6.9 (15.2)	11.6 (25.6)	94.0
Bed 1B[d]	Low	1,960	90	402	126 (278)	5.8 (12.8)	10.4 (22.9)	94.0
	High	4,370	214	541	265 (584)	13.0 (28.7)	13.2 (29.1)	94.3
Bed 2A[d,f]	Low	2,330	124	616	150 (331)	8.0 (17.6)	16.0 (35.3)	92.9
	High	5,100	333	1,165	310 (684)	20.2 (44.5)	28.5 (62.8)	91.3
Bed 2B[c,d,f]	High	4,235	158	444	257 (567)	9.6 (21.2)	10.9 (24.0)	95.5
Bed 3A[e]	Low	2,093	48	204	117 (258)	2.6 (5.7)	5.3 (11.7)	97.1
	High	4,780	132	412	252 (556)	6.9 (15.2)	10.1 (22.3)	96.6
Bed 3B[e]	Low	2,260	34	161	126 (278)	1.9 (4.2)	4.2 (9.3)	98.0
	High	5,010	161	306	264 (582)	8.5 (18.7)	7.5 (16.5)	96.2

[a] Expressed as a 50/50 mole percent mixture of THF and toluene, the major constituents of the five-component solvent formulation.

[b] Bed not operated during high inlet concentration level under normal conditions.

[c] Bed not operated during low inlet concentration level under normal conditions.

[d] Carbon service life of 5 months.

[e] Carbon service life of 1-2 weeks.

[f] Carbon in beds 2A and 2B was contaminated with a heavy fouling compound, according to plant personnel.

TABLE C-5. CARBON ADSORBER OPERATING PARAMETERS FOR IBM FACILITY

Parameter	Design value		Actual value	
SLA flow rate, m^3/s (acfm)				
Nominal	NA[a]		6.85	(13,700)
Maximum	7.5	(15,000)	7.5	(15,000)
SLA inlet temperature °C (°F)	29-32	(85-90)	29	(85)
SLA inlet, % relative humidity	55		55	
SLA inlet concentration, ppmv				
Typical	30		6	
Maximum	65		21	
Carbon lifetime, months	N/A[b]		60	
Total carbon charge, kg (lb)	N/A		17,237	(38,000)

[a] NA = not available.
[b] N/A = not applicable.

TABLE C-6. SUMMARY OF CARBON ADSORBER EFFICIENCIES FOR IBM FACILITY IN 1982

Month	Control device efficiency, %
January	94.2
February	94.2
March	95.0[a]
April	95.0[a]
May	98.3
June	99.0
July	98.6
August	98.7
September	99.1
October	99.4
November	98.5
December	97.7

[a] Estimated.

TABLE C-7. CARBON ADSORBER OPERATING PARAMETERS FOR 3M FACILITY

Parameter	Carbon adsorber No. 1 values		Carbon adsorber No. 2 values	
SLA flow rate, m^3/s (acfm)				
Maximum	8.0	(16,000)	4.0	(8,000)
SLA inlet temperature, °C (°F)	43	(110)	38	(100)
SLA inlet, % relative humidity	50-65		50-65	
SLA inlet concentration, ppmv				
Typical	400		125	
Maximum	1,200		375	
Carbon lifetime, months	18		60	
Total carbon charge, kg (lb)	29,030	(64,000)	9,072	(20,000)

TABLE C-8. SUMMARY OF CARBON ADSORBER RECOVERY EFFICIENCIES FOR 3M FACILITY[a]

Month	Control device No. 1, %	Control device No. 2, %
1	94	96
2	96	96
3	97	96
4	96	95
5	95	95
6	94	94
7	92	94
8	90	93
9	91	93
10	90	91
11	90	91
12	89	90

[a] Control device efficiency data are at end of adsorption cycle, which has the lowest efficiency at this point.

TABLE C-9. CALCULATION OF THE AMOUNT OF SOLVENT APPLIED DURING COMPLIANCE TEST AT ALLIED MEDIA TECHNOLOGY

Parameter	Line No. 1		Line No. 2	
Coating thickness, μm (mil)	3.1	(0.125)	4.1	(0.165)
Coating speed, m/s (ft/min)	1.0	(200)	0.8	(150)
Coating time, min	226		149	
Coating width, cm (in.)	31.1	(12.25)	31.1	(12.25)
Coating formulation, % solids by wt.	32		32	
Coating usage, kg/m^2 (lb/ft^2)	0.037	(0.0075)	0.037	(0.0075)
Solvent density, kg/ℓ (lb/gal)	0.88	(7.35)	0.88	(7.35)
Solvent use, kg (lb)	66.7	(147)	43.5	(96)

TABLE C-10. CALCULATION OF AMOUNT OF SOLVENT RECOVERED DURING COMPLIANCE TEST AT ALLIED MEDIA TECHNOLOGY

Parameter	Value kg	 (lb)
Total weight of drum and collected solvent	118	(260)
Drum tare weight	12.5	(27.6)
Weight of solvent collected before time of test	3	(6.6)
Total solvent recovered	105.5	(232.6)

TABLE C-11. SUMMARY OF COATING LINE OPERATIONS AT PSTL FACILITY

	Line number				
	1	2	3	4	Total
Line width, m	1.42	0.71	0.71	0.71	
(in.)	(56)	(28)	(28)	(28)	
Number of runs	25	68	23	24	140
Average line speed, m/s	0.21	0.24	0.24	0.22	0.23
(ft/min)	(41)	(46.5)	(46.5)	(42.5)	(44.8)
Average weight percent solvent	57.5	62.2	66.0	62.4	60.3
Total solvent used[a]					
kg	12,750	4,915	3,747	2,309	23,723
(lb)	(28,110)	(10,837)	(8,262)	(5,091)	(52,300)
ℓ	15,630	5,761	4,323	3,017	28,731
(gal)	(4,129)	(1,522)	(1,142)	(797)	(7,589)

[a] Measured during 4-week test period.

APPENDIX D - EMISSION MEASUREMENT AND MONITORING

APPENDIX D - EMISSION MEASUREMENT AND MONITORING

This appendix describes the measurement method experience that was gained during the emission testing portion of this study, recommended performance test procedures, and potential continuous monitoring procedures. The purposes of these descriptions are to define the methodologies used to collect the data, to recommend potential procedures to demonstrate compliance with a new source performance standard, and to discuss alternatives for monitoring either emissions or process parameters to indicate continued compliance with that standard.

D.1 EMISSION MEASUREMENT TEST PROGRAM AND METHODS

No emission source testing in the magnetic tape industry was conducted by the Emission Standards and Engineering Division (ESED) of the Environmental Protection Agency (EPA) as part of the background support study for the new source performance standard for this industry. However, testing had been conducted earlier by ESED/EPA in similar surface coating industries, and similar test procedures would be applicable for the magnetic tape industry.

D.1.1 Coating Analysis Testing

Coating samples were received from three magnetic tape manufacturers, and analyzed using EPA Reference Method 24. All samples were high-solvent coatings; no low-solvent or waterborne coatings were available. Preliminary analysis indicates that Method 24 is applicable to these coatings, although specialized techniques and equipment may be needed. [More details will be provided later when method development and analyses are completed.]

Extensive analysis of coating samples from other surface coating industries has been done. Coating samples were received from paint and ink manufacturers and users in the following industries: automobile and light-duty truck, metal coil, can, large appliances, pressure-sensitive tapes and labels, and flexible vinyl coating. The coatings types included high-solvent, high-solids, waterborne, and solvent-waterborne coatings. These sample coatings encompassed the range of coatings expected in the respective industries. All the samples were analyzed using EPA Reference Method 24.

The analysis results generally compared well with the manufacturers' formulation data. Because the expected composition of magnetic tape coatings is similar to the coatings tested, Method 24 should be applicable to the magnetic tape industry.

D.1.2 Emission Source Testing Programs

Although no magnetic tape plants were tested, emission tests for volatile organic compounds (VOC) were conducted at several plants in similar coating industries: automobile and light-duty truck, metal coil, can, pressure-sensitive tapes and labels, publication rotogravure, and flexible vinyl coating. Because similar test procedures would be applicable to the magnetic tape industry, details of these test programs in other industries are discussed below.

For each individual facility that was tested, the test procedures and approaches varied somewhat due to different data needs and plant design configurations. In general, the purpose of the testing programs was to characterize the VOC emissions to the atmosphere and the control efficiency of the vapor capture and processing systems, as well as the overall solvent usage, end distribution, and material balance throughout the entire coating process. The field testing was usually much more comprehensive than the performance test procedures specified in the applicable regulations for these industries in order to evaluate various testing approaches and methods and to gather useful auxiliary information to better understand the process operation.

D.1.3 Stack Emission Testing Conducted

D.1.3.1 Testing Locations. Gas streams that were tested for VOC concentrations and flow rate included: inlets and outlets of vapor processing devices; uncontrolled exhaust streams venting directly to the atmosphere; intermediate process streams such as hood exhausts and drying oven exhausts venting to other process units. From the concentration and flow rate results, the VOC mass emissions or mass flow rate in each stream could be calculated. Not all of these streams were tested at each plant. The streams selected for sampling at a particular plant depended on the data needs of that particular industry testing program. These gas streams were usually in vents that were suitable for conventional EPA stack emission measurement techniques, and these measurement approaches are described in this section.

If there were emissions that were not collected and vented through stacks suitable for conventional testing, then ambient VOC survey techniques had to be adopted. (An example would be open doorways.) These nonconventional measurement techniques are described in a later section, D.1.5.

D.1.3.2 Flow Measurements. During ESED/EPA's field testing programs, Reference Methods 1, 2, 3, and 4 were used to determine the volumetric flow rate of the gas streams being sampled. Because all the stacks or ducts that were tested had diameters of at least 12 inches, Methods 1 and 2 were applicable, and alternative flow rate measurement techniques were not required. The volumetric flow rates were determined on either a dry or wet basis, depending on whether the corresponding VOC concentration method used for that site measured VOC concentrations under actual conditions (wet basis) or dry conditions.

Reference Method 1 was used to select the sampling site along the duct or stack, and to determine the number of sampling points on the cross-sectional area inside the duct. Method 2 was used to measure gas velocity. This method is based on the use of an S-type pitot tube to traverse the duct cross-section to calculate an average gas velocity. To determine the gas stream molecular weight and density, as required for Method 2, the fixed gases composition and moisture content are needed. The fixed gas composition (O_2, CO_2, CO, N_2) was usually determined by an Orsat analysis procedure detailed in Method 3. Sometimes, however, the molecular weight of the vent gases was assumed to be the same as ambient air. This was a valid assumption when no combustion sources were involved and the hydrocarbon concentrations in the stream were low. Gas stream moisture was measured following Method 4, or with a wet bulb/dry bulb approach. The less precise wet bulb/dry bulb technique was acceptable because the moisture value was not usually a crucial parameter in these tests. Also, the moisture content was not expected to differ from ambient conditions unless combustion sources were involved. The moisture content is used to adjust the molecular weight in a calculation step in Method 2, and to adjust the flow rates to a dry basis if needed. Using the duct area, the gas volumetric flow rate was then calculated.

If the flow rate in a vent were suspected to be unsteady and vary significantly during a test run, then Method 2 was modified to give an indication of the continuous flow rate. The pitot tube was left in the duct at a single representative sampling point so that any changes in the flow rate could be monitored.

D.1.3.3 Concentration Measurements. The VOC concentration in each stack was determined using one or more of the following methods:

- ° Reference Method 25 (M25)
- ° Flame Ionization Analyzer (FIA)
  - ° Reference Method 25A (M25A)
  - ° Modified calibration procedures following a more general method detailed in an EPA guideline document (GENERAL FIA)
  - ° Continuous measurements using direct extraction (CONT/FIA)
  - ° Time integrated bag samples (BAG/FIA)
- ° Reference Method 18 - Gas Chromatograph (GC) with flame ionization detector
  - ° Time integrated bag samples (BAG/GC)
  - ° Grab flask or syringe samples (GRAB/GC)

It should be noted that at the time of the testing, many of these methods had not been finalized, so preliminary versions were followed. However, the later changes to these methods were not significant and would not have affected the test results. Usually, two of the VOC measurement procedures were run simultaneously. This was done in order to characterize the emissions in more detail, as well as to aid in selecting an appropriate test method.

The direct extraction FIA method was used at sites which were convenient and not in hazardous areas. The direct FIA had the advantage that, with continuous measurements, minor process variations could be noted.

Also, once it was set up, it was relatively inexpensive to run it for a long time period, and thus, changes in emissions due to process variations could be easily noted.

The other methods could be used at any sampling location, including sites in explosive atmospheres or remote locations. When the time-integrated sampling methods were used (M25, BAG/FIA, BAG/GC), the sample was collected for a 45- to 60-minute time period. Because of its complex analysis procedure, the Method 25 samples had to be analyzed later in the laboratory. The integrated bag samples, however, were analyzed as soon as possible (within 24 hours) on-site by either a FIA or GC method.

The FIA's were usually calibrated with propane, although sometimes they were also calibrated with the solvent being used in the coating process, (GENERAL FIA). The GC's were calibrated with each component that was known to be in the solvent mixture being used.

The results from the different FIA sampling approaches should be equivalent, provided they are compared for the same time periods. The Method 25 results differed somewhat from the results of the FIA. The differences were probably due to the fact that the Method 25 procedure measures all carbon atoms equally, while the FIA detector has a varying response ratio for different organic compounds. The difference in results would be most pronounced when a multi-component solvent mixture is used.

The results from the two GC sampling approaches would necessarily be different because of the different sampling time periods. The results from a GC analysis are reported as concentrations for each individual compound, and thus cannot be compared directly to the FIA results. The FIA is calibrated with one compound and the total hydrocarbon concentration is reported as one number on the basis of that compound. Also, the FIA detector has a varying response ratio to different organic compounds, so again the difference in results between the GC and FIA would be most pronounced when a multi-component solvent mixture is used.

D.1.4 Liquid Solvent Material Balance Testing Conducted

The EPA did not directly conduct any long-term liquid solvent material balance tests; however, detailed records were obtained from three plants in two industries and EPA reviewed their procedures. In all cases, the vapor recovery device was a carbon absorber. The solvent used by the plant was compared to the solvent recovered (usually on a weekly or monthly basis), in order to obtain an overall control efficiency, combining capture and recovery efficiencies. At one plant in the pressure-sensitive tapes and labels industry, the amount of solvent recovered was determined by reading the level in the solvent recovery tank at the carbon adsorber. The amount of solvent used was determined from plant purchasing, inventory, and production records. At two plants in the publication rotogravure industry, in-line meters measured the amount of solvent directed to each printing line and the recovered solvent returned to the solvent storage tank.

D.1.5 Ambient Surveys and Fugitive Emission Characterization

Ambient measurements were conducted during some test series. Open doorways were monitored periodically to estimate the mass flux of VOC into and out of the coating area. The flow rate through doorways was measured with a hand-held velometer (6 to 9 points were sampled per doorway). Concentration was measured with a portable combustible gas detector which generally conformed to Reference Method 21 specifications.

Ambient VOC concentration levels in the coating area were measured periodically during the testing period. The surveys were conducted throughout the room at various heights (1, 5, and 8 feet from floor).

Surveys were also made of the VOC concentrations and flow rates into hood intakes above coating or embossing operations, in order to estimate and characterize the fugitive VOC's which were drawn into the hooding exhaust stack. VOC concentration and flow measurements were made at representative spots around the perimeter of intake hoods as close to the intake as the physical equipment setup permitted.

Eight-hour exposure sampling was conducted during some test programs. Following a NIOSH ambient sampling procedure, ambient air samples were drawn through carbon tubes. Analysis consisted of extraction in carbon disulfide and liquid analysis by gas chromatograph for speciation of the solvent components used in the coatings.

D.1.6 Solvent Sample Analysis

Some plants mix their coatings on-site from raw materials. Samples of the solvent (or mixture of solvents) were obtained and analyzed for speciation by direct injection into a gas chromatograph. The results from these analyses indicated whether the solvent (or solvent mixture) being used matched the plant's formulation data.

Samples of recovered solvent from carbon adsorbers were also obtained and analyzed in order to compare the composition of the recovered solvent to that of the new solvent.

D.1.7 Wastewater Sample Analysis

If the solvents being used were miscible in water, then the recovered solvent from a steam-generated carbon adsorber is mixed with water and is separated in a distillation step. Wastewater samples were collected from various points in the carbon adsorption/distillation system. The water samples were analyzed for compound speciation and total organic carbon using standard laboratory water analysis procedures.

The results from this determination were used to characterize the operation of the carbon adsorber and applied to the solvent material balance calculations.

D.1.8 Product Sample Analysis

Product samples were collected and analyzed for residual solvent content in two industries. The results from this determination were applied to the solvent material balance calculations.

In the pressure sensitive tapes and labels industry, final tape samples were collected and analyzed for residual solvent, using ASTM F 151-72 "Standard Test Method for Residual Solvents in Flexible Barrier Material." This method only provided an index for comparing solvent levels and was inappropriate for the true measurement of the mass of residual solvent.

In the flexible vinyl printing and coating industry, product samples of the vinyl wall covering were obtained before and after the embosser and analyzed for solvent content. The test procedure was an adaptation of NIOSH ambient carbon tube measurement techniques. The product samples were put in a heated container and air was drawn across the container and then through a carbon tube, which collected the organics. The carbon tubes were analyzed for compound speciation by a gas chromatograph, in the same manner as ambient sample carbon tubes. This product sampling and analysis was a preliminary test procedure. The results were in a lower range than expected, but there is no way to independently verify the results.

D.2 PERFORMANCE TEST METHODS

Many different approaches, test methods, and test procedures can be used to characterize volatile organic compound (VOC) emissions from industrial surface coating facilities. The particular combination of measurement methods and procedures to be used depends upon the format of the standard and test procedures specified in the applicable regulation.

General testing approaches are:

1. Analysis of coatings.
2. Direct measurement of emissions to the atmosphere from stacks.
3. Determination of vapor processing device efficiency.
4. Determination of vapor capture system efficiency.
5. Determination of overall control efficiency based on liquid solvent material balance.
6. Survey of fugitive emissions.

D.2.1 Performance Testing of Coatings

D.2.1.1 Analysis of Coatings

Recommended Method. EPA Reference Method 24 is the recommended method for the analysis of coatings. This method combines several American Society of Testing and Materials (ASTM) standard methods to determine the volatile matter content, water content, density, volume solids, and weight solids of inks and related surface coatings. These parameter values are combined to calculate the VOC content of a coating in the units specified in the applicable regulation.

Reference Method 24A is similar in principle to Method 24, but some of the analytical steps are slightly different and the results would differ. It was developed specifically for publication rotogravure printing inks and contains specific analytical steps which were already widely used in that industry. Thus, Reference Method 24A is not recommended for analysis of magnetic tape coatings.

Volatile Matter Content (W_v). The total volatile content of a coating is determined by using ASTM D 2369-81, "Standard Test Method for Volatile Content of Coatings." This procedure is applied to both aqueous and nonaqueous coatings. The result from this procedure is the volatile content of a coating as a weight fraction.

Water Content(W_w). There are two acceptable procedures for determining the water content of a coating: (1) ASTM D 3792-80, "Standard Test Method for Water Content of Water-Reducible Paints by Direct Injection into a Gas Chromatograph," and (2) ASTM D 4017-81, "Standard Test Method for Water in Paints and Paint Materials by the Karl Fischer Titration Method." This procedure is applied only to aqueous coatings. The result is the water content as a weight fraction.

Organic Content (W_o). The volatile organic content of a coating (as a weight fraction) is not determined directly. Instead, it is determined indirectly by subtraction from the total volatile content and the water content values.

$$W_o = W_v - W_w$$

Solids Content (W_s). The solids content of a coating (as a weight fraction) is also determined indirectly using the previously determined values:

$$W_s = 1 - W_v = 1 - W_o - W_w$$

Volume Solids (V_s). There is no reliable, accurate analytical procedure that is generally applicable to determine the volume solids of a coating. Instead, the solids content (as a volume fraction) is calculated using the manufacturer's formulation data.

Coating Density (D_c). The density of coating is determined using the procedure in ASTM D 1475-60 (Reapproved 1980), "Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products."

Cost. The estimated cost of analysis per coating sample is: $50 for the total volatile matter content procedure; $100 for the water content determination; and $25 for the density determination. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

Adjustments. If non-photochemically reactive solvents are used in the coatings, then standard gas chromatographic techniques may be used to identify and quantify these solvents. The results of Reference Method 24 may be adjusted to subtract these solvents from the measured VOC content.

D.2.1.2 Sampling and Handling of Coatings. For Method 24 analysis of a coating, a 1-liter sample should be obtained and placed in a 1-liter container. The head-space in the container should be as small as possible so that organics in the coating do not evaporate and escape detection. The coating sample should be taken at a place that is representative of the coating being applied. Alternatively, the coating may be sampled in the mixing or storage area while separate records are kept of dilution solvent being added at the coating heads. Some magnetic tape coatings have a component (usually a resin) that cause the coating to "set" within a short time period. Samples of these coatings need to be taken before the "setting agent" has been added.

The coating sample should be protected from direct sunlight, extreme heat or cold, and agitation. There is no limitation given in Method 24 for the length of time between sampling and analysis.

D.2.1.3 Weighted Average VOC Content of Coatings. If a plant uses all low-solvent coatings (as specified in the applicable regulation), then each coating simply needs to be analyzed following Method 24. However, if a plant uses a combination of low and high-solvent coatings, the weighted average VOC content of all the coatings used over a specified time period needs to be determined. Depending on the format of the standard, the average is weighted by the volume or mass of coating solids. In addition to the Method 24 or manufacturer's formulation information, the amount (as a weight) of each coating used must be determined. The EPA has no independent test procedure to determine the amount of coating used, and instead it is recommended that plant inventory and usage records be relied upon. Most plants already keep detailed records of amounts of coatings used. Thus, no additional effort or cost is expected to be required to attain coating usage. If a plant keeps its inventory records on a volume basis, then the density of the coating needs to be determined to convert the inventory to a mass basis.

D.2.2 Stack Emission Testing

D.2.2.1 Testing Locations. Stack emission testing techniques would be needed to measure the VOC concentration and gas flow rate in stacks and ducts such as: inlets and outlets of vapor processing devices; exhaust streams from mixing equipment and/or storage tanks; uncontrolled exhaust streams venting directly to the atmosphere; intermediate process streams such as hood exhausts and drying oven exhausts venting to other process units. The particular streams to be measured depends upon the applicable regulation.

D.2.2.2 Use of Test Results. The results from the VOC concentration measurement and flow rate measurement can be combined and used in many ways. If a regulation is on a concentration basis, then only VOC concentration measurement is needed and the result can be used directly. If the regulation is on a mass emission basis (i.e., mass emitted per unit of production; or mass emitted per unit of time), then the concentration and flow rate results are combined to calculate the mass flow rate. If the regulation is on an efficiency basis, then mass flow rate is determined for each of the streams being compared and the efficiency is calculated straightforwardly.

The performance test procedure in the applicable regulation will define the test length and the conditions under which testing is acceptable, as well as the way the reference test method measurements are combined to attain the final result.

D.2.2.3 Overall Control Efficiency. Performance test methods and procedures are used to determine the overall control efficiency of the add-on pollution control system. The add-on control system is composed of two parts: a vapor capture system, and a vapor processing device (carbon adsorber, condenser, or incinerator). The control efficiency of each component is determined separately and the overall control efficiency is the product of the capture system and processing device efficiencies. (Note: This measured overall control efficiency will not reflect control or emission reductions due to process and operational changes.)

D.2.2.4 Processing Device Efficiency. The three types of processing devices that are expected to be used in the magnetic tape industry are carbon adsorbers, condensers, and incinerators. The test procedure to determine efficiency is the same for each control technology.

To determine the efficiency of the emission processing device, the VOC mass flow rate in the inlet and outlet gas streams must be determined. To determine the mass of VOC in a gas stream, both the concentration and flow rate must be measured. The recommended methods and the reason for their selection are discussed later in sections D.2.2.7 and D.2.2.8.

D.2.2.5 Capture System Efficiency. The efficiency of the vapor capture system is defined as the ratio of the mass of gaseous VOC emissions directed to the vapor processing device to the total mass of gaseous VOC emissions from the magnetic tape coating line. The mass of VOC in each applicable vent is determined by measuring the concentration and the flow rate using standard EPA test methods. The recommended methods and the reason for their selection are discussed later in sections D.2.2.7 and D.2.2.8.

In order to determine capture efficiency, all fugitive VOC emissions from the coating area must be captured and vented through stacks suitable for testing. Furthermore, the coating line being tested should be isolated from any fugitive VOC emissions originating from other sources. All doors and other openings through which fugitive VOC emissions might escape would be closed.

One way to isolate the coating line from other VOC emission sources and to capture and vent all fugitive emissions from the coating line is to construct a temporary enclosure with a separate vent around those portions of the coating line (e.g. flashoff area) where fugitive emissions normally occur. The temporary enclosure should be ventilated at a rate proportional to that of the building in which the enclosure is housed in order to duplicate closely the normal emissions profile. Although this method of measuring capture efficiency may not produce conditions identical to normal operation, the rate of generation of "fugitive" emissions within the temporary enclosure will tend to be lower than without the enclosure. The enclosure walls will reduce cross drafts resulting in a conservatively high estimate of capture efficiency.

Instead of requiring a performance test, a regulation may require a specific equipment configuration in order to ensure a high capture efficiency. For example, the applicable regulation may specify a total enclosure around the coater or sealed lids and a closed venting system for coating mix equipment. To ensure that these equipment specifications are met, visible inspections or Method 21 leak detection surveys can be conducted. However, ESED/EPA has no experience using Method 21 for detecting such leaks in the surface coating industries, and thus cannot recommend a leak concentration level to be used in evaluating the performance of various pieces of capture equipment.

D.2.2.6 Stack Emission Testing - Time and Cost. The length of a performance test is specified in the applicable regulation and is selected to be representative for the industry and process being tested. The length of a perfomance test should be selected to be long enough so to account for variability in emissions due to up and down operation times, routine process problems, and different products. Also, the performance test time period should correspond to the cycles of the emission control device.

Coating line operations are intermittent; there are often long time periods between runs for cleanup, setup, and color matching, so the total length of a performance test could vary from plant to plant. In general, a performance test would consist of three to six runs, each lasting from 1/2 to 3 hours. It is estimated that for most operations, the field testing could probably be completed in 2 to 3 days (i.e., two or three 8-hour work shifts) with an extra day for setup, instrument preparation, and cleanup.

The cost of the testing varies with the length of the test and the number of vents to be tested: inlet, outlet, intermediate process, and fugitive vents. The cost to measure VOC concentration and flow rate is estimated at $6,000 to $10,000 per vent, excluding travel expenses.

D.2.2.7 Details on Gas Volumetric Flow Measurement Method.

Recommended methods. Reference Methods 1, 1A, 2, 2A, 2C, 2D, 3 and 4 are recommended as appropriate for determination of the volumetric flow rate of gas streams.

Large stacks with steady flow. Methods 1 and 2 are used in stacks with steady flow and with diameters greater than 12 inches. Reference Method 1 is used to select the sampling site, and Reference Method 2 measures the volumetric flow rate using a S-type pitot tube velocity traverse technique. Methods 3 and 4 provide fixed gases analysis and moisture content, which are used to determine the gas stream molecular weight and density in Method 2. The results are in units of standard cubic meters per hour.

Small ducts. If the duct is small (less than 12 inches diameters) then alternative flow measurement techniques will be needed using Method 2A, Method 2D, or Methods 2C and 1A. Method 2A uses an in-line turbine meter to continuously and directly measure the volumetric flow. Method 2D uses rotameters, orifice plates, anemometers, or other volume rate or pressure drop measuring devices to continuously measure the flowrate. Methods 1A and 2C (in combination) modify Methods 1 and 2 and use a small standard pitot tube traverse technique to measure the flow in small ducts, and apply when the flow is constant and continuous.

Unsteady flow. If the flow in a large duct (greater than 12 inches diameter) is not steady or continuous, then Method 2 may be modified to continuously monitor the changing flow rate in the stack. A continuous 1-point pitot tube measurement is made at a representative location in the stack. For small ducts with unsteady flow, continuous measurement with Method 2A or 2D is recommended.

Adjustment for moisture. The results do not need to be adjusted to dry conditions (using Method 4 for moisture) if the VOC concentrations are measured in the gas stream under actual conditions; that is, if the VOC concentrations are reported as parts of VOC per million parts of actual (wet) volume (ppmv). If the concentrations are measured on a dry basis (gas chromatographic techniques or Method 25) then the volumetric flow rate must correspondingly be adjusted to a dry basis.

D.2.2.8 Details on VOC Concentration Measurement Method.

Method 25A. The recommended VOC measurement method is Reference Method 25A, "Determination of Total Gaseous Organic Concentration Using A Flame Ionization Analyzer" (FIA). This method was selected because it measures the expected solvent emissions accurately, is practical for long-term, intermittent testing, and provides a continuous record of VOC concentration. A continuous record is valuable because of coating line and control device fluctuations. Measurements that are not continuous may not give a representative indication of emissions. The coating lines in this industry may operate intermittently, and the vent concentrations may vary significantly. Continuous measurements and records are easier to use for intermittent processes, and the short-term variations in concentration can be noted. The continuous records are averaged or integrated as necessary to obtain an average result for the measurement period.

Method 25A applies to the measurement of total gaseous organic concentration of vapors consisting of alkanes, and/or arenes (aromatic hydrocarbons). The instrument is calibrated in terms of propane or another appropriate organic compound. A sample is extracted from the source through a heated sample line and glass fiber filter and routed to a flame ionization analyzer (FIA). (Provisions are included for eliminating the heated sampling line and glass fiber filter under some sampling conditions.) Results are reported as concentration equivalents of the calibration gas organic constitutent or organic carbon.

Instrument calibration is based on a single reference compound. For the magnetic tape industry, the recommended calibration compound is propane or butane. (However, if only one compound is used as the sole solvent at a plant, then that solvent could be used as the calibration compound.) As a result, the sample concentration measurements are on the basis of that reference compound and are not necessarily true hydrocarbon concentrations. The response of an FIA is proportional to carbon content for similiar compounds. Thus, on a carbon number basis, measured concentrations based on the reference compound are close to the true hydrocarbon concentrations. Also, any minor biases in the FIA concentration results are less significant if the results will be used in an efficiency calculation -- both inlet and outlet measurements are made and compared -- and biases in each measurement will tend to cancel out. For calculation of emissions on a mass basis, results would be nearly equivalent using either the concentration and molecular weight based on a reference gas or the true concentration and true average molecular weight of the hydrocarbons.

The advantage of using a single component calibration is that costly and time consuming chromatographic techniques are not required to isolate and quantify the individual compounds present. Also, propane and butane calibration gases are readily available in the concentration ranges needed for this industry.

The solvents commonly used in coatings in this industry are methylethylketone (MEK), methyl-iso-butyl ketone (MIBK), toluene, cyclohexanone, and tetrahydrofuran (THF). Most plants use a mixture of different compounds for solvent. Since the solvent mixtures may vary from day-to-day and from plant-to-plant, there is no standard solvent mixture to use for calibration. Also, the individual compounds in the mixture will evaporate and be controlled at different rates, so the gaseous VOC mix in the exhaust stream is not the same mix as the original multi-component liquid solvent. Furthermore, if incineration is used, any semi-destructed gaseous compounds at the incinerator outlet will be different from the compounds in the original solvent mixture. Thus, there is no advantage in calibrating the FIA with the mixture of solvents being used.

The analysis technique using an FIA measures total hydrocarbons including methane and ethane, which are considered non-photochemically reactive, and thus not VOC's. Due to the coating solvent composition, little methane or ethane is expected in the gas streams so chromatographic analysis is not needed nor recommended to adjust the hydrocarbon results to a nonmethane, nonethane basis.

Other Methods. Three other VOC concentration measurement methods were considered (and rejected) for this application: Method 18, Method 25B, and Method 25.

Method 18. Gas chromatograph (GC) analysis on integrated bag samples following Method 18 was considered because results would be on the basis of true hydrocarbon concentrations for each compound in the solvent mixture. However, the BAG/GC sample technique is not a continuous measurement and would be cumbersome and impractical because of the length of the testing. Also, it would be costly and time consuming to calibrate for each compound, and there is little advantage or extra accuracy gained from the GC approach.

Method 25B. Method 25B, "Determination of Total Gaseous Organic Concentration Using a Nondispersive Infrared Analyzer," is identical to Method 25A except that a different instrument is used. Method 25B applies to the measurement of total gaseous organic concentration of vapor consisting primarily of alkanes. The sample is extracted as described in Method 25A and is analyzed with a nondispersive infrared analyzer (NDIR). Method 25B was not selected because NDIR analyzers do not respond as well as FIA's to all of the solvents used in this industry. Also, NDIR's are not sensitive in low concentration ranges (<50 ppmv), and the outlet concentrations from incinerators and carbon adsorbers are expected to often be below 50 ppmv.

Method 25. Method 25, "Determination of Total Gaseous Nonmethane Organics Content" was also considered. A 30- to 60-minute integrated sample is collected in a sample train, and the train is returned to the laboratory for analysis. The collected organics are converted in several analytical steps to methane and the number of carbon atoms (less methane in the original sample) is measured. Results are reported as organic carbon equivalent concentration. The Method 25 procedure is not recommended for this industry because it is awkward to use for long test periods and it takes integrated samples instead of continuously sampling and recording the concentration. Concentration variations would be masked with Method 25 time-integrated sample. Also, Method 25 is not sensitive in low concentration ranges (<50 ppmv). However, Method 25 has the advantage that it counts each carbon atom in each compound and does not have a varying response ratio for different compounds.

D.2.3 Liquid Solvent Material Balance

If a plant's vapor processing device recovers solvent (such as carbon adsorption or condensor systems) then a liquid solvent material balance approach can be used to determine the efficiency of the vapor control system. This is done by comparing the solvent used versus the solvent recovered. These values may be obtained from a plant's inventory records. The EPA has no test procedure to independently verify the plant's accounting records. However, it is recommended that the plant set up and submit to the enforcement agency its proposed inventory accounting and recordkeeping system prior to any performance testing.

For this performance testing approach, the averaging time (performance test time period) usually needs to be 1 week to 1 month. This longer averaging period allows for a representative variety of coatings and tape products, as well as reducing the impact of short-term variations due to process upsets, solvent spills, and variable amounts of solvent in use in the process.

The volume of solvent recovered may be determined by measuring the level of solvent in the recovered solvent storage tank. The storage tank should have an accurate, easily readable level indicator. To improve the precision of the volume measurement, it is recommended that the recovered solvent tank have a relatively small diameter, so that small changes in volume result in greater changes in tank level. Alternatively, the solvent recovered may be measured directly by using a liquid volume meter in the solvent return line. Adjustments to the amount of solvent recovered may be needed to match the format of the applicable regulation. For example, if the regulation applies to only certain unit operations in a plant, then the contributions of other VOC sources must be subtracted from the total amount of solvent recovered.

The volume of solvent used may be determined from plant inventory and purchasing records or by measuring the level in the solvent storage tank. Alternatively, a liquid volume meter can be used to measure the amount of solvent drawn off from the solvent storage tank. Adjustments to the amount of solvent used may be needed to match the format of the applicable regulation. For example, the regulation may apply to only certain unit operations in a plant, or to only solvent applied at the coater not to solvent used for cleanup.

D.3 MONITORING SYSTEMS AND DEVICES

The purpose of monitoring is to ensure that the emission control system is being properly operated and maintained after the performance test. One can either directly monitor the regulated pollutant, or instead, monitor an operational parameter of the emission control system. The aim is to select a relatively inexpensive and simple method that will indicate that the facility is in continual compliance with the standard.

The three types of vapor processing devices that are expected to be used in the magnetic tape industry are carbon adsorbers, condensers, and incinerators. Possible monitoring approaches and philosophy for each part of the VOC control system are discussed below.

D.3.1 Monitoring of Vapor Processing Devices

D.3.1.1 Monitoring in Units of Efficiency. There are presently no demonstrated continuous monitoring systems commercially available which monitor vapor processor operation in the units of efficiency. This monitoring would require measuring not only inlet and exhaust VOC concentrations, but also inlet and exhaust volumetric flow rates. An overall cost for a complete monitoring system is difficult to estimate due to the number of component combinations possible. The purchase and installation cost of an entire monitoring system (including VOC concentration monitors, flow measurement devices, recording devices, and automatic data reduction) is estimated to be $25,000. Operating costs are estimated at $25,000 per year. Thus, monitoring in the units of efficiency is not recommended due to the potentially high cost and lack of a demonstrated monitoring system.

D.3.1.2 Monitoring in Units of Mass Emitted. Monitoring in units of mass of VOC emitted would require concentration and flow measurements only at the exhaust location, as discussed above. This type of monitoring system has not been commercially demonstrated. The cost is estimated at $12,500 for purchase and installation plus $12,500 annually for operation, maintenance, calibration, and data reduction.

D.3.1.3 Monitoring of Exhaust VOC Concentration. Monitoring equipment is commercially available, however, to monitor the operational or process variables associated with vapor control system operation. The variable which would yield the best indication of system operation is VOC concentration at the processor outlet. Extremely accurate measurements would not be required because the purpose of the monitoring is not to determine the exact outlet emissions but rather to indicate operational and maintenance practices regarding the vapor processor. Thus, the accuracy of a FIA (Method 25A) type instrument is not needed, and less accurate, less costly instruments which use different detection principles are acceptable. Monitors for this type of continuous VOC measurements, including a continuous recorder, typically cost about $6,000 to purchase and install, and $6,000 annually to calibrate, operate, maintain, and reduce the data. To achieve representative VOC concentration measurements at the processor outlet, the concentration monitoring device should be installed in the exhaust vent at least two equivalent stack diameters from the exit point, and protected from any interferences due to wind, weather, or other processes.

The EPA does not currently have any experience with continuous monitoring of VOC exhaust concentration of vapor processing units in the magnetic tape industry. Therefore, performance specifications for the sensing instruments cannot be recommended at this time. Examples of such specifications that were developed for sulfur dioxide and nitrogen oxides continuous instrument systems can be found in Appendix B of 40 CFR 60.

D.3.1.4 Monitoring of Process Parameters. For some vapor processing systems, there may be another process parameter besides the exhaust VOC concentration which is an accurate indicator of system operation. Because control system design is constantly changing and being upgraded in this industry, all acceptable process parameters for all systems cannot be specified. Substituting the monitoring of vapor processing system process parameters for the monitoring of exhaust VOC concentration is valid and acceptable if it can be demonstrated that the value of the process parameter is an indicator of proper operation of the vapor processing system. However, a disadvantage of parameter monitoring alone is that the correlation of the parameters with the numerical emission limit is not exact. Monitoring of any such parameters would have to be approved by enforcement officials on a caseby-case basis. Parameter monitoring equipment would typically cost about $3,000 plus $3,000 annually to operate, maintain, periodically calibrate, and reduce the data into the desired format. Temperature monitoring equipment is somewhat less expensive. The cost of purchasing and installing an accurate temperature measurement device and recorder is estimated at $1,500. Operating costs, including maintenance, calibration, and data reduction, would be about $1,500 annually.

D.3.1.5 Monitoring of Carbon Adsorbers. For carbon adsorption vapor processing devices, the preferred monitoring approach is the use of a continuous VOC exhaust concentration monitor. However, as discussed above, no such general monitor has been demonstrated for the many different organic compounds encountered in this industry. Alternatively, the carbon bed temperature (after regeneration and completion of any cooling cycles), and the amount of steam used to regenerate the bed have been identified as indicators of product recovery efficiency. Temperature monitors and steam flow meters which indicate the quantity of steam used over a period of time are available.

D.3.1.6 Monitoring of Condensers. For condenser devices, the temperature of the exhaust stream has been identified as an indicator of product recovery efficiency, and condenser temperature monitors are available.

D.3.1.7 Monitoring of Incinerators. For incineration devices, the exhaust concentration is quite low and is difficult to measure accurately with the inexpensive VOC monitors. Instead, the firebox temperature has been identified and demonstrated to be a process parameter which reflects level of emissions from the device. Thus, temperature monitoring is the recommended monitoring approach for incineration control devices. Since a temperature monitor is usually included as a standard feature for incinerators, it is expected that this monitoring requirement will not incur additional costs to the plant.

D.3.1.8 Use of Monitoring Data. The use of monitoring data is the same regardless of whether the VOC outlet concentration or an operational parameter is selected to be monitored. The monitoring system should be installed and operating properly before the first performance test. Continual surveillance is achieved by comparing the monitored value of the concentration or parameter to the value which occurred during the last successful performance test, or alternatively, to a preselected value which is indicative of good operation. It is important to note that a high monitoring value does not positively confirm that the facility is out of compliance; instead, it indicates that the emission control system or the coating process is operating in a different manner than during the last successful performance test.

The averaging time for monitoring purposes should be related to the time period for the performance test.

D.3.2 Monitoring of Vapor Capture Systems

D.3.2.1 Monitoring in Units of Efficiency. Monitoring the vapor capture system in the units of efficiency would be a difficult and costly procedure. This monitoring approach would require measuring the VOC concentration and volumetric flow rate in the inlet to the vapor processing device and in each fugitive VOC vent and then combining the results to calculate an efficiency for each time period. Such a monitoring system has not been commercially demonstrated. The purchase and installation of an entire monitoring system is estimated at $12,500 per stack, with an additional $12,500 per stack per year for operation, maintenance, calibration, and data reduction. Thus, monitoring in the units of efficiency is not recommended.

D.3.2.2 Monitoring of Flow Rates. As an alternative, an operational parameter could be monitored instead. The key to a good capture system is maintaining proper flow rates in each vent. Monitoring equipment is commercially available which could monitor these flow rate parameters. Flow rate monitoring equipment for each vent would typically cost about $3,000 plus $3,000 annually to operate, maintain, periodically calibrate, and reduce the data into the desired format. The monitored flow rate values are then compared to the monitored value during the last successful performance test.

Proper flow rates and air distribution in a vapor capture system could also be ensured by an inspection and maintenance program, which generally would not create any additional cost burden for a plant. In that case, the additional value of information provided by flow rate monitors would probably be minimal. Routine visual inspections of the fan's operation would indicate whether or not capture efficiencies remain at the performance test level, and no formal monitoring of the air distribution system would be required.

If a total enclosure is specified in the applicable regulation to ensure proper capture, then the proper operation of the total enclosure can be monitored. Examples of monitoring devices include VOC concentration detectors inside the enclosure, pressure sensors inside the enclosure, flow rate meters in ducts, and fan amperage meters.

D.3.3 Monitoring of Overall Control System Efficiency on a Liquid Basis

If a plant uses a vapor recovery control device, the efficiency of the overall plant control (combined vapor capture and vapor recovery systems) can be monitored using a liquid material balance. The amount of solvent used is compared to the amount of solvent recovered. (These amounts may need to be adjusted to match the format of the applicable regulation.) These values are obtained from a plant's inventory records. For this monitoring approach, the averaging time or monitoring period usually needs to be 1 week to 1 month. This longer averaging period is necessary to coordinate with a plant's inventory accounting system and to eliminate short-term variations due to process upsets, solvent spills, and variable amounts of solvent in use in the process.

Because most plants already keep good solvent usage and inventory records, no additional cost to the plant would be incurred for this monitoring approach.

D.3.4 Monitoring of Coatings

If a plant elects to use low-solvent content coatings in lieu of control devices, then the VOC content of the coatings should be monitored. There is no simplified way to do this. Instead, the recommended monitoring procedure is the same as the performance test: the plant must keep records of the VOC content and amount of each coating used and calculate the weighted average VOC content over the time period specified in the regulation. As an alternative, the plant could set up a sampling program so that random samples of coatings would be analyzed using Reference Method 24.

D.4 TEST METHOD LIST AND REFERENCES

The EPA testing methods that are mentioned in this Appendix are listed below with their complete title and reference.

D.4.1 Reference Methods in Appendix A - 40 CFR 60

Method 1 - Sample and Velocity Traverses for Stationary Sources.
Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube).
Method 2A - Direct Measurement of Gas Volume Through Pipes and Small Ducts.
Method 3 - Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight.
Method 4 - Determination of Moisture in Stack Gases.
Method 18 - Measurement of Gaseous Organic Compound Emissions by Gas Chromatography.
Method 21 - Determination of Volatile Organic Compound Leaks.
Method 24 - Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings.
Method 24A- Determination of Volatile Matter Content and Density of Printing Inks and Related Coatings.
Method 25 - Determination of Total Gaseous Nonmethane Organic Emissions as Carbon.
Method 25A- Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer.
Method 25B- Determination of Total Gaseous Organic Concentration Using a Nondispersive Infrared Analyzer.

D.4.2 Proposed Methods for Appendix A - 40 CFR 60

Method 1A - Sample and Velocity Traverses for Stationary Sources With Small Stacks or Ducts (Proposed on 10/21/83, 48 FR 48955).

Method 2C - Determination of Stack Gas Velocity and Volumetric Flow Rate From Small Stacks and Ducts (Standard Pitot Tube) (Proposed on 10/21/83, 48 FR 48956).

Method 2D - Measurement of Gas Volume Flow Rates in Small Pipes and Ducts (Proposed on 10/21/83, 48 FR 48957).

D.4.3 Other Methods

° General Measurement of Total Gaseous Organic Compound Emissions Using a Flame Ionization Analyzer, in "Measurement of Volatile Organic Compounds Supplement 1," OAQPS Guideline Series, EPA Report No. 450/3-82-019, July 1982.

APPENDIX E--ENVIRONMENTAL AND ENERGY IMPACTS OF THE CONTROL OPTIONS

APPENDIX E
ENVIRONMENTAL AND ENERGY IMPACTS OF THE CONTROL OPTIONS

The environmental and energy impacts of the control options for the individual emission sources at the magnetic tape coating model lines (solvent storage tanks, mix preparation equipment, and coating operation) are presented in this Appendix. The assumptions used to calculate these impacts were presented in Chapter 7. The environmental and energy impacts of the regulatory alternatives that result from combining the impacts of the various storage tank, mix equipment, and coating operation control options also were presented in Chapter 7.

Tables E-1 through E-3 present the control option configurations and control levels for the three emission sources: storage tanks, mix equipment, and coating operation, respectively. Table E-4 presents the annual VOC emission levels, and Table E-5 presents the 1990 estimated national annual VOC emissions for all possible control options for each emission source. Tables E-6 through E-9 present the annual wastewater discharges, annual waterborne VOC emissions, and the 1990 estimated national wastewater and waterborne VOC emissions, respectively. The annual and estimated 1990 national annual solid waste impacts for the three emission sources are presented in Tables E-10 and E-11.

Tables E-12 through E-15 present the annual electrical energy, natural gas, steam, and total energy requirements for the emission sources. The 1990 national annual energy demand is presented in Table E-16. Tables E-17 and E-18 present the annual secondary pollutants resulting from the generation of electrical energy for the mix equipment and coating operation. The requirements for storage tanks were negligible. The secondary pollutants from the magnetic tape coating line are presented in Table E-19. The annual secondary pollutants from the combustion of natural gas for the coating operation and line are presented in Table E-20. There are no control options requiring the use of natural gas (i.e., incinerators) for the storage tanks and mix equipment. The annual secondary pollutants from steam generation are presented in Tables E-21 through E-24 for the storage tanks, mix equipment, coating operation, and line.

TABLE E-1. CONTROL OPTION CONFIGURATIONS AND CONTROL LEVELS FOR SOLVENT STORAGE TANKS FOR IMPACT ANALYSIS*

Control option	Control device	Overall VOC control,[a] %
1	None	0
2	Conservation vents	35[b]
3A	Separate fixed-bed carbon adsorber on storage storage tank emissions alone	95
3B	Common fixed-bed carbon adsorber on combined storage tank and coating operation emissions	95

[a] Of emissions from solvent storage tanks only, not from entire line.

[b] Average control efficiency based on model line solvents and tank sizes.

*The control options for solvent storage tanks have been revised. See Table F-2 in Appendix F.

TABLE E-2. CONTROL OPTION CONFIGURATIONS AND CONTROL LEVELS FOR MIX EQUIPMENT FOR IMPACT ANALYSIS

Control option	Control device			Overall VOC control,[b] %
	Mixers	Mills[a]	Tanks	
1	None			0
2	Vapor tight covers with conservation vents[c]			40
3A	Vapor tight covers ducted to a separate fixed-bed carbon adsorber on mix room emissions alone			95
3B	Vapor tight covers ducted to a common fixed-bed carbon adsorber on combined mix room and coating operation emissions			95

[a] For mills other than sealed and pressurized sand mills.

[b] Of emissions from mix room only, not from entire line.

[c] The equipment has no areas that are directly open to the air. This may be achieved by use of packing glands, tight covers, or lids on the equipment.

TABLE E-3. CONTROL OPTION CONFIGURATIONS AND CONTROL LEVELS FOR COATING OPERATIONS FOR IMPACT ANALYSIS

Control option	Emission capture system		Control device	Overall VOC control,[b] %
	Coating area	Drying oven[a]		
1A (baseline)	None	No	None	0
1B (baseline)	None	Yes	Carbon adsorber or condenser	83
2A	Partial enclosure	Yes	Carbon adsorber	87
2B	Partial enclosure	Yes	Condenser[c]	87
3A	Total enclosure	Yes	Carbon adsorber	93
3B	Total enclosure	Yes	Condenser[c,d]	93
4	Total enclosure	Yes	Incinerator	95

[a] Assumed to be well designed oven with no losses to room; always vented to the control device in controlled plants.

[b] Of emissions from coating operation only, not the entire line.

[c] Condenser A used to control effluent from enclosure and from oven.

[d] Condenser B used to control effluent from nitrogen purged total enclosure and effluent from drying oven with nitrogen atmosphere.

TABLE E-4. SUMMARY OF ANNUAL VOC EMISSION LEVELS

Control option	Emission level[a]					
	Research		Small		Typical	
	Mg	ton	Mg	ton	Mg	ton
SOLVENT STORAGE TANKS*						
1	0.03	0.03	0.05	0.05	0.39	0.43
2	0.02	0.02	0.03	0.03	0.25	0.28
3A	0.002	0.002	0.002	0.002	0.02	0.02
3B	0.002	0.002	0.002	0.002	0.02	0.02
MIX EQUIPMENT						
1	2.7	3.0	7.3	8	70.7	78.0
2	1.6	1.8	4.4	4.8	42.4	46.8
3A	0.14	0.15	0.36	0.4	3.5	3.9
3B	0.14	0.15	0.36	0.4	3.5	3.9
COATING OPERATION						
1A	23	25	68	75	635	700
1B	4	4	12	13	108	119
2A	3	3	9	10	83	91
2B	3	3	9	10	83	91
3A	2	2	5	5	44	49
3B	2	2	5	5	44	49
4	1	1	4	4	32	35

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[a] Metric and English units may not convert exactly due to independent rounding.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-3 in Appendix F for these revisions.

TABLE E-5. ESTIMATED 1990 NATIONAL VOC EMISSIONS[a,b]

Control	Research		Small		Typical		Total	
option	Mg	ton	Mg	ton	Mg	ton	Mg	ton
SOLVENT STORAGE TANKS*								
1	0.03	0.03	0.25	0.25	4.29	4.73	4.57	5.01
2	0.02	0.02	0.15	0.15	2.75	3.08	2.92	3.25
3A	0.002	0.002	0.01	0.01	0.22	0.22	0.23	0.23
3B	0.002	0.002	0.01	0.01	0.22	0.22	0.23	0.23
MIX EQUIPMENT								
1	2.7	3.0	37	40	778	858	820	900
2	1.6	1.8	22	24	468	515	490	540
3A	0.14	0.15	2	2	39	43	40	40
3B	0.14	0.15	2	2	39	43	40	40
COATING OPERATION								
1A	23	25	340	375	6,985	7,700	7,350	8,100
1B	4	4	60	65	1,188	1,309	1,250	1,380
2A	3	3	45	50	913	1,001	960	1,050
2B	3	3	45	50	913	1,001	960	1,050
3A	2	2	25	25	484	539	510	570
3B	2	2	25	25	484	539	510	570
4	1	1	20	20	352	385	370	410

---

[a] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[b] Metric and English units may not convert exactly due to independent rounding.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 through F-4 for these revisions.

TABLE E-6. ANNUAL WASTEWATER DISCHARGES[a,b]

Control option	Research[c]		Small[c]		Typical	
	10^3 ℓ	10^3 gal	10^3 ℓ	10^3 gal	10^3 ℓ	10^3 gal
SOLVENT STORAGE TANKS*						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A	0	0	0	0	0	0
4B	0	0	0	0	2	0.5
MIX EQUIPMENT						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A[d]	0	0	0	0	0	0
3B	0	0	0	0	200	50
COATING OPERATION						
1A	0	0	0	0	0	0
1B	0	0	0	0	1,590	420
2A	0	0	0	0	1,670	440
2B	0	0	0	0	0	0
3A	0	0	0	0	1,780	470
3B	0	0	0	0	0	0
4	0	0	0	0	0	0

---

[a] Wastewater results from the operation of fixed-bed carbon adsorbers.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[d] Wastewater containing solvent is disposed as hazardous waste.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-12 for these revisions.

TABLE E-7. ANNUAL WATERBORNE VOC EMISSIONS[a,b]

Control option	Emission level[c]					
	Research[d]		Small[d]		Typical	
	kg	lb	kg	lb	kg	lb
			SOLVENT STORAGE TANKS*			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	0	0	0	0	0	0
3B	0	0	0	0	0.1	0.2
			MIX EQUIPMENT			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A[e]	0	0	0	0	0	0
3B	0	0	0	0	20	40
			COATING OPERATION			
1A	0	0	0	0	0	0
1B	0	0	0	0	160	350
2A	0	0	0	0	170	370
2B	0	0	0	0	0	0
3A	0	0	0	0	180	390
3B	0	0	0	0	0	0
4	0	0	0	0	0	0

---

[a] Waterborne VOC emissions result from the operation of fixed-bed carbon adsorbers.

[b] Wastewater from stripper column of distillation system contains 100 ppm VOC.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[e] Wastewater containing solvent is disposed as hazardous waste.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-12 for these revisions.

TABLE E-8. ESTIMATED 1990 NATIONAL WASTEWATER DISCHARGES[a,b]

Control option	10^3 ℓ[c]	10^3 gal[c]
SOLVENT STORAGE TANKS*		
1	0	0
2	0	0
3A	0	0
3B	11	3.3
MIX EQUIPMENT		
1	0	0
2	0	0
3A[d]	0	0
3B	2,200	550
COATING OPERATION		
1A	0	0
1B	17,490	4,620
2A	18,370	4,840
2B	0	0
3A	19,580	5,170
3B	0	0
4	0	0

[a] Wastewater results from the operation of fixed-bed carbon adsorbers.

[b] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Wastewater containing solvent is disposed as hazardous waste.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-12 for these revisions.

TABLE E-9. ESTIMATED 1990 NATIONAL WATERBORNE VOC EMISSIONS[a,b]

Control option	Emission level[c] lb[d]	Emission level[c] kg[d]
SOLVENT STORAGE TANKS*		
1	0	0
2	0	0
3A	0	0
3B	1	2
MIX EQUIPMENT		
1	0	0
2	0	0
3A[e]	0	0
3B	220	470
COATING OPERATION		
1A	0	0
1B	1,800	3,800
2A	1,900	4,100
2B	0	0
3A	2,000	4,300
3B	0	0
4	0	0

---

[a] Waterborne VOC emissions result from the operation of fixed-bed carbon adsorbers.

[b] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Wastewater from stripper column of distillation system contains 100 ppm VOC.

[e] Wastewater containing solvent is disposed as hazardous waste.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-12 for these revisions.

TABLE E-10. ANNUAL SOLID WASTE IMPACTS[a]

Control option	Research[b]		Small[b]		Typical[b]	
	kg	lb	kg	lb	kg	lb
			SOLVENT STORAGE TANKS*			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A[c]	90	190	150	320	980	2,150
3B[d]	0	0	0	0	0	0
			MIX EQUIPMENT			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	9	20	9	20	58	120
3B	9	20	9	20	58	120
			COATING OPERATION			
1A	0	0	0	0	0	0
1B[e]	71	160	71	160	700	1,550
1B[f]	0	0	0	0	1,820	4,000
2A[e]	73	160	73	160	730	1,600
2B[f]	0	0	0	0	1,820	4,000
3A[e]	76	170	76	170	780	1,700
3B[f]	0	0	0	0	1,820	4,000
4	0	0	0	0	0	0

---

[a] Solid waste results from the operation of fixed-bed and fluidized-bed carbon adsorbers.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Disposable canister carbon adsorber.

[d] Negligible.

[e] For fixed-bed carbon adsorbers.

[f] For fluidized-bed carbon adsorbers only on typical sized line.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-13 for these revisions.

TABLE E-11. ESTIMATED NATIONAL 1990 SOLID WASTE IMPACTS[a]

Control option	Mg[b]	Ton[b]
SOLVENT STORAGE TANKS*		
1	0	0
2	0	0
3A[c]	12	13
3B[d]	0	0
MIX EQUIPMENT		
1	0	0
2	0	0
3A	0.7	0.7
3B	0.7	0.7
COATING OPERATION		
1A	0	0
1B[e]	8.2	9.0
1B[f]	20.0	22.0
2A[e]	8.4	9.3
2B[f]	20.0	22.0
3A[e]	9.0	9.9
3B[f]	20.0	22.0
4	0	0

---

[a] Solid waste results from the operation of fixed-bed and fluidized-bed carbon adsorbers.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Disposable canister carbon adsorber.

[d] Negligible.

[e] For fixed-bed carbon adsorbers.

[f] For fluidized-bed carbon adsorbers only on typical sized line.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-13 for these revisions.

TABLE E-12. ANNUAL ELECTRICAL ENERGY REQUIREMENTS

Control option	Control device[a]	Research[b] GJ[c]	Research[b] 10^6 Btu	Small[b] GJ[c]	Small[b] 10^6 Btu	Typical[b] GJ[c]	Typical[b] 10^6 Btu
			SOLVENT STORAGE TANKS				
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA[d]	0	0	0	0	0	0
3B	CA[d]	0	0	0	0	0	0
			MIX EQUIPMENT				
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0.367	0.348	1.6	1.5	2.1	2.0
3B	CA	0.367	0.348	1.6	1.5	2.1	2.0
			COATING OPERATION[e]				
1A	None	0	0	0	0	0	0
1B	CA	16	15	48	46	505	479
1B	RF	N/A[f]	N/A	N/A	N/A	3,780	3,590
1B	N_2	N/A	N/A	N/A	N/A	301	286
2A	CA	16	15	48	46	505	479
2B	RF	N/A	N/A	N/A	N/A	3,780	3,590
3A	CA	16	15	48	46	505	479
3B	RF	N/A	N/A	N/A	N/A	3,780	3,590
3B	N_2	N/A	N/A	N/A	N/A	301	286
4	INC	5	4	14	13	140	133

[a] CV = conservation vent; CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] GJ = Gigajoules or 10^9 joules; one joule = 0.948 x10^{-3} Btu.

[d] Negligible.

[e] Condensation systems cannot be designed for research and small lines.

[f] N/A = Not applicable.

TABLE E-13. ANNUAL NATURAL GAS REQUIREMENTS FOR THE CONTROL EQUIPMENT OF MODEL MAGNETIC TAPE COATING OPERATIONS

Control option[a]	Research[b]		Small[b]		Typical[b]	
	GJ[c]	10^6 Btu	GJ[c]	10^6 Btu	GJ[c]	10^6 Btu
4	500	470	1,500	1,420	15,000	14,200

[a] Only control option requiring the combustion of natural gas.

[b] Metric and English units may not convert exactly due to independent rounding.

TABLE E-14. ANNUAL STEAM REQUIREMENTS

Control option	Control device[a]	Research[b]		Small[b]		Typical[b]	
		GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
				SOLVENT STORAGE TANKS*			
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0	0	0	0	0	0
3B	CA	0.26	0.25	0.44	0.42	3.78	3.60
				MIX EQUIPMENT			
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	26	25	70	67	687	652
3B	CA	26	25	70	67	687	652
				COATING OPERATION[c]			
1A	None	0	0	0	0	0	0
1B	CA	193	183	578	548	10,040	9,520
1B[d]	RF	N/A[e]	N/A	N/A	N/A	4,640	4,400
1B[d]	N_2	N/A	N/A	N/A	N/A	4,640	4,400
2A	CA	201	191	605	574	10,290	9,760
2B[d]	RF	N/A	N/A	N/A	N/A	4,640	4,400
3A	CA	216	205	647	614	10,678	10,129
3B[d]	RF	N/A	N/A	N/A	N/A	4,640	4,400
3B[d]	N_2	N/A	N/A	N/A	N/A	4,640	4,400
4	INC	0	0	0	0	0	0

[a] CV = conservation vents; CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Condensation systems cannot be designed for research and small lines.

[d] Steam requirements for condensation distillation system on typical lines.

[e] N/A = Not applicable.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-14 for these revisions.

TABLE E-15. TOTAL ANNUAL ENERGY DEMAND

Control option	Control device[a]	Research[b]		Small[b]		Typical[b]	
		GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
			SOLVENT STORAGE TANKS*				
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0	0	0	0	0	0
3B	CA	0.26	0.25	0.44	0.42	3.78	3.60
			MIX EQUIPMENT				
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	26	25	72	69	689	654
3B	CA	26	25	72	69	689	654
			COATING OPERATION[c]				
1A	None	0	0	0	0	0	0
1B	CA	209	198	626	594	10,500	10,000
1B	RF	N/A[d]	N/A	N/A	N/A	8,420	7,990
1B	N_2	N/A	N/A	N/A	N/A	4,940	4,690
2A	CA	217	206	653	620	10,800	10,240
2B	RF	N/A	N/A	N/A	N/A	8,420	7,990
3A	CA	232	220	695	659	11,180	10,610
3B	RF	N/A	N/A	N/A	N/A	8,420	7,990
3B	N_2	N/A	N/A	N/A	N/A	4,950	4,690
4	INC	505	474	1,510	1,430	15,140	14,330

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[a] CV = conservation vents; CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Condensation systems cannot be designed for research and small lines.

[d] Not applicable.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-14 for these revisions.

TABLE E-16. ESTIMATED NATIONAL 1990 ENERGY DEMAND

Control option	Control device[a]	Electrical[b]		Natural gas[b]		Steam[b]		Total[b]	
		GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
SOLVENT STORAGE TANKS*									
1	None	0	0	0	0	0	0	0	0
2	CV	0	0	0	0	0	0	0	0
3A	CA	0	0	0	0	0	0	0	0
3B	CA	0	0	0	0	44	42	44	42
MIX EQUIPMENT									
1	None	0	0	0	0	0	0	0	0
2	CV	0	0	0	0	0	0	0	0
3A	CA	32	30	0	0	7,940	7,530	7,970	7,560
3B	CA	32	30	0	0	7,940	7,530	7,970	7,560
COATING OPERATION[c]									
1A	None	0	0	0	0	0	0	0	0
1B	CA	5,810	5,510	0	0	113,540	107,640	119,350	113,150
1B	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
1B	N_2	3,320	3,150	0	0	51,050	48,400	54,370	51,550
2A	CA	5,810	5,510	0	0	116,480	110,420	122,290	115,930
2B	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
3A	CA	5,810	5,510	0	0	120,980	114,690	126,790	120,200
3B	RF	41,580	39,490	0	0	51,050	48,400	92,630	87,890
3B	N_2	3,320	3,150	0	0	51,050	48,400	54,370	51,550
4	INC	1,610	1,530	173,000	163,770	0	0	174,610	165,300

[a] CV = conservation vents; CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Condensation systems cannot be designed for research and small lines.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-14 for these revisions.

TABLE E-17. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM THE GENERATION OF ELECTRICAL ENERGY FOR CONTROL OF MIX EQUIPMENT

Control option	Control device[a]	Emission levels[b] PM[c] kg	PM[c] lb	SO_x kg	SO_x lb	NO_x kg	NO_x lb
	Research						
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0.01	0.03	0.4	1	0.3	0.60
3B	CA	0.01	0.03	0.4	1	0.3	0.60
	Small						
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0.06	0.14	2	5	1	3
3B	CA	0.06	0.14	2	5	1	3
	Typical						
1	None	0	0	0	0	0	0
2	CV	0	0	0	0	0	0
3A	CA	0.08	0.18	3	7	2	4
3B	CA	0.08	0.18	3	7	2	4

[a] CV = conservation vent; CA = carbon adsorber.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] PM = particulate matter.

TABLE E-18. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM THE GENERATION OF ELECTRICAL ENERGY FOR CONTROL OF COATING OPERATIONS

		Emission levels[b]					
		PM		SO_x		NO_x	
Control option	Control device[a]	kg	lb	kg	lb	kg	lb
	Research[c]						
1A	None	0	0	0	0	0	0
1B, 2A, 3A	CA	0.4	1	20	50	10	30
4	INC	0.2	0.4	40	10	4	10
	Small[c]						
1A	None	0	0	0	0	0	0
1B, 2A, 3A	CA	2	4	80	170	40	80
4	INC	0.4	1	20	50	10	20
	Typical						
1A	None	0	0	0	0	0	0
1B, 2A, 3A	CA	20	40	790	1,740	400	870
1B, 2B, 3B	RF	150	330	5,930	13,050	2,970	6,530
1B, 3B	N_2	10	30	470	1,040	240	520
4	INC	4	10	220	480	110	240

[a] CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Condensation systems cannot be designed for research and small lines.

TABLE E-19. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM THE GENERATION OF ELECTRICAL ENERGY FOR CONTROL OF MODEL MAGNETIC TAPE COATING LINES

Control option[a]	Coating operation control device[b]	Emission levels[c]					
		PM		SO_x		NO_x	
		kg	lb	kg	lb	kg	lb
	Research[d]						
I	None	0	0	0	0	0	0
II	None	0	0	0	0	0	0
III[e]	None	0.01	0.03	0.4	1	0.3	0.60
IV, V, VI, VII, VIII, XIA, IX, IXB, XIII	CA	0.4	1	30	60	10	30
X, XII	INC	0.2	0.4	40	10	4	10
XIV	INC	0.2	0.4	10	20	4	10
	Small[d]						
I	None	0	0	0	0	0	0
II	None	0	0	0	0	0	0
III[e]	None	0.06	0.14	2	5	1	3
IV, V, VI, VII, VIII, XIA, IX, XIB, XIII	CA	2	4	80	170	40	80
X, XII	INC	0.4	1	20	50	10	20
XIV	INC	0.4	1	20	50	10	30
	Typical						
I	None	0	0	0	0	0	0
II	None	0	0	0	0	0	0
III[e]	None	0.08	0.18	3	7	2	4
IV, V, VI, VII, VIII, XIA	CA	20	40	790	1,740	400	870
IV, V, VI, VII, VIII, XIA	RF	150	330	5,930	13,050	2,970	6,530
IV, VI, VIII, XIA	N_2	10	30	480	1,050	240	530
IX, XIB, XIII	CA	20	40	790	1,740	400	870
IX, XIB, XIII	RF	150	330	5,930	13,050	2,970	6,530
IX, XIII	N_2	10	30	480	1,050	240	530
X, XII	INC	4	10	210	470	110	240
XIV	INC	4	10	210	470	110	240

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[a] The regulatory alternatives and corresponding control device configurations for coating lines are presented in Table 6-10.

[b] CA = Carbon adsorber.
RF = condensation-air refrigeration system.
N_2 = condensation-nitrogen atmosphere system.
INC = Incinerator.

[c] Metric and English units may not convert exactly due to independent rounding.

[d] Condensation systems cannot be designed for research and small lines.

[e] Energy requirements are for carbon adsorbers used to control mix equipment emissions.

TABLE E-20. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM THE COMBUSTION OF NATURAL GAS FOR CONTROL OF COATING OPERATIONS AND LINE[a]

Control option[b]	Emission levels[c]					
	PM		CO		NO_x	
	kg	lb	kg	lb	kg	lb
			Research			
4	4	10	4	10	60	130
			Small			
4	10	20	20	40	180	400
			Typical			
4	100	230	180	400	1,840	4,050

[a] The coating operation and line have the same requirements because there are no control options requiring natural gas for mix equipment and storage tanks.

[b] Only regulatory alternative requiring the combustion of natural gas.

[c] Metric and English units may not convert exactly due to independent rounding.

TABLE E-21. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM STEAM GENERATION FOR CONTROL OF SOLVENT STORAGE TANKS*

Control option	Emission levels[a]					
	PM		SO_x		NO_x	
	kg	lb	kg	lb	kg	lb
Research						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	0	0	0	0	0	0
3B	0.017	0.038	0.22	0.49	0.05	0.12
Small						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	0	0	0	0	0	0
3B	0.03	0.06	0.4	0.8	0.1	0.2
Typical						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	0	0	0	0	0	0
3B	0.2	0.5	3	7	0.9	2

[a] Metric and English units may not convert exactly due to independent rounding.

*The control options and environmental impacts for solvent storage tanks have been revised. See Tables F-2 and F-15 for these revisions.

TABLE E-22. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM STEAM GENERATION FOR CONTROL OF MIX EQUIPMENT

Control option	Emission levels[a]					
	PM		SO_x		NO_x	
	kg	lb	kg	lb	kg	lb
Research						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	2	4	20	50	4	10
3B	2	4	20	50	4	10
Small						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	4	10	60	130	10	30
3B	4	10	60	130	10	30
Typical						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3A	40	100	580	1,280	150	330
3B	40	100	580	1,280	150	330

[a] Metric and English units may not convert exactly due to independent rounding.

TABLE E-23. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM STEAM GENERATION FOR CONTROL OF COATING OPERATION

Control option	Control device[a]	Emission levels[b]					
		PM		SO_x		NO_x	
		kg	lb	kg	lb	kg	lb
	Research[c]						
1A	None	0	0	0	0	0	0
1B	CA	10	30	160	360	40	90
2A	CA	10	30	170	370	40	100
3A	CA	10	30	180	400	40	100
4	INC	0	0	0	0	0	0
	Small[c]						
1A	None	0	0	0	0	0	0
1B	CA	40	80	490	1,070	120	270
2A	CA	40	90	510	1,130	130	290
3A	CA	40	90	540	1,200	140	310
4	INC	0	0	0	0	0	0
	Typical						
1A	None	0	0	0	0	0	0
1B	CA	650	1,430	8,490	18,680	2,160	4,760
1B	RF	300	660	3,930	8,640	1,000	2,200
1B	N_2	300	660	3,930	8,640	1,000	2,200
2A	CA	660	1,460	8,700	19,150	2,200	4,880
2B	RF	300	660	3,930	8,640	1,000	2,200
3A	CA	690	1,520	9,040	19,880	2,300	5,060
3B	RF	300	660	3,930	8,640	1,000	2,200
3B	N_2	300	660	3,930	8,640	1,000	2,200
4	INC	0	0	0	0	0	0

[a] CA = carbon adsorber; RF = condensation--air refrigeration system; N_2 = condensation--nitrogen purged system; INC = incinerator.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Condensation systems cannot be designed for research and small lines.

TABLE E-24. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM STEAM GENERATION FOR CONTROL OF MODEL MAGNETIC TAPE COATING LINES

Control option[a]	Emission levels[b]					
	PM		SO_x		NO_x	
	kg	lb	kg	lb	kg	lb
			Research			
III	2	4	20	50	4	10
IV	10	30	160	350	40	90
V	10	30	170	370	40	90
VI	10	30	160	350	40	90
VII	10	30	170	370	40	90
VIII	10	30	190	410	40	100
IX	10	30	190	410	40	100
XIA	10	30	190	410	40	100
XIB	10	30	200	430	50	110
XIII	10	30	200	450	50	120
XIV	2	4	20	50	4	10
			Small			
III	4	10	60	130	10	30
IV	40	80	490	1,080	120	270
V	40	90	510	1,120	130	280
VI	40	80	490	1,080	120	270
VII	40	90	510	1,120	130	280
VIII	40	90	550	1,220	140	300
IX	40	90	550	1,220	140	310
XIA	40	90	550	1,220	140	300
XIB	40	100	570	1,260	140	320
XIII	40	100	600	1,330	150	340
XIV	4	10	60	130	10	30
			Typical			
III	40	100	580	1,280	140	320
IV[c]	650	1,430	8,490	18,680	2,160	4,760
IV[d]	300	660	3,930	8,640	1,000	2,200
V[c]	660	1,460	8,700	19,150	2,200	4,880
V[d]	300	660	3,930	8,640	1,000	2,200

(continued)

TABLE E-24. (continued)

	Emission levels[b]					
Control option[a]	PM		SO_x		NO_x	
	kg	lb	kg	lb	kg	lb
VI[c]	650	1,430	8,490	18,680	2,160	4,760
VI[d]	300	660	3,930	8,640	1,000	2,200
VII[c]	660	1,460	8,700	19,150	2,220	4,880
VII[d]	300	660	3,930	8,640	1,000	2,200
VIII[c]	690	1,520	9,040	19,880	2,300	5,060
VIII[d]	300	660	3,930	8,640	1,000	2,200
IX[c]	690	1,520	9,070	19,960	2,310	5,080
IX[d]	340	760	4,500	9,910	1,140	2,520
XIA[c]	690	1,520	9,040	19,880	2,300	5,060
XIA[d]	300	660	3,930	8,640	1,000	2,200
XIB[c]	710	1,560	9,290	20,430	2,360	5,200
XIB[c]	340	760	4,500	9,910	1,140	2,520
XIII[c]	740	1,620	9,620	21,160	2,450	5,390
XIII[d]	340	760	4,500	9,910	1,140	2,520
XIV	40	100	580	1,280	140	320

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[a] The regulatory alternatives and corresponding control device configurations for coating lines are presented in Table 6-10.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] For fixed-bed carbon adsorber. Typical line includes distillation requirements.

[d] For condensation system distillation requirements.

APPENDIX F--IMPACTS FOR CONTROL OF SOLVENT STORAGE TANKS

APPENDIX F

IMPACTS FOR CONTROL OF SOLVENT STORAGE TANKS

The control options and the environmental and cost impacts for control of solvent storage tanks that were presented in Chapters 6 through 8 and Appendix E have been revised. These revisions were not integrated into those chapters. Instead, they are presented in this appendix.

The model storage tank parameters are presented in Table F-1. The control options for storage tanks are presented in Table F-2. Control option 1 (baseline) is an uncontrolled storage tank. Control option 2 requires installation of a conservation vent set at 17.2 kPa (2.5 psig) pressure and 0.215 kPa (0.5 ounces) vacuum on a properly designed tank. At this setting, all breathing emissions are eliminated, but working losses are uncontrolled. This option results in an average control efficiency of 50 percent for the model solvents and tank sizes. Installation of a pressure relief valve set at 103 kPa (15 psig) (control option 3), which would eliminate all breathing losses and approximately 80 percent of the working losses, results in an average control efficiency of 90 percent. The installation of a 103 kPa (15 psig) pressure relief valve requires the use of a tank of different design from the atmospheric tanks used at lower pressure. Thus, the control system using either the pressure relief valve or the conservation vent consists of the valve plus the tank. Control options 4A and 4B require the venting of all tank emissions to a separate, disposable carbon adsorption system and to a carbon adsorber controlling coating operation emissions, respectively.

Tables F-3 and F-4 present the annual VOC emission levels and the 1990 estimated national VOC emission levels for the model storage tanks (group of tanks), respectively. The amount and value of recovered solvent are presented in Table F-5. The capital and annualized costs of conservation vents for control of solvent storage tank emissions are presented in Tables F-6 and F-7. Because a similar type of tank is used for both the baseline and conservation vent options, the only cost elements considered for control option 2 are the vent itself and the solvent that is prevented from escaping.

For control option 3 (the installation of a pressure relief valve), the cost of the entire control system of valve plus tank must be compared to the cost of the vent and tank control system of control option 2 (installation of a conservation vent). The installed costs for the two types of tanks for various sizes are presented in Table F-8. Within the accuracy of these estimates, the two types of tanks for control options 2 and 3 cost the same. There is a difference of a few hundred dollars in the cost of the two types of vents. However, in comparing the control systems (vent plus tank), the cost of the vents is within the variability of the tank cost estimates. Thus, there is no capital cost increase for installing a pressure vessel system compared to a conservation vent/atmospheric tank system. Therefore, the only factor considered in the annualized costs of pressure relief valves for control of solvent storage tanks is the value of the solvent that is prevented from escaping. The annualized costs are a net credit ranging from $31/yr for the research model plant to $793/yr for the typical model plant (see Table F-5).

The capital and annualized costs for control option 4A (separate, disposable carbon adsorber) are presented in Tables F-8a and F-8b, respectively. The capital and annualized costs for control option 4B (common carbon adsorber) are presented in Tables F-8c and F-8d, respectively.

Table F-9 summarizes the total installed capital and annualized costs for the storage tank control options and also presents the annualized cost per unit area of tape coated. Tables F-10 and F-11 present the average and incremental cost effectiveness of the solvent storage tank control options, respectively.

There are no wastewater discharges, waterborne VOC emissions, energy requirements, or secondary pollutants for the conservation vent or pressure relief valve control options. The wastewater, solid waste, energy requirements, and secondary air pollutant emissions for control options 4A and 4B are presented in Tables F-12 through F-15.

TABLE F-1. MODEL SOLVENT STORAGE TANK PARAMETERS

Line designation:	Research	Small	Typical
Solvent usage, m^3/yr (gal/yr)	23 (6,130)	70 (18,400)	700 (184,000)
No. of different solvents used	5	3	3
No. of storage tanks	5	3	3
Capacity of each tank, m^3 (gal)	4 (1,000)	4 (1,000)	40 (10,000)
Emissions, Mg/yr (ton/yr)	0.027 (0.03)	0.045 (0.05)	0.69 (0.76)

TABLE F-2. CONTROL OPTIONS FOR SOLVENT STORAGE TANKS

Control option	Control device	Overall VOC control,[a] %
1	None	0
2	Conservation vent, 17.2 kPa (2.5 psig)	65[b]
3	Pressure relief valve, 103 kPa (15 psig)	90[b]
4A	Separate fixed-bed carbon adsorber on storage tank emissions alone	95
4B	Common fixed-bed carbon adsorber on combined storage tank and coating operation emissions	95

[a] Of emissions from solvent storage tanks only, not the entire line.

[b] Average control efficiency based on model line solvents and tank sizes.

TABLE F-3. SUMMARY OF ANNUAL STORAGE TANK VOC EMISSION LEVELS

Control option	Emission level[a]					
	Research		Small		Typical	
	Mg	ton	Mg	ton	Mg	ton
1	0.027	0.03	0.045	0.05	0.69	0.76
2	0.009	0.011	0.016	0.018	0.24	0.27
3	0.003	0.003	0.005	0.005	0.07	0.08
4A	0.002	0.002	0.002	0.002	0.03	0.04
4B	0.002	0.002	0.002	0.002	0.03	0.04

[a] Metric and English units may not convert exactly due to independent rounding.

TABLE F-4. ESTIMATED 1990 NATIONWIDE STORAGE TANK VOC EMISSIONS[a,b]

Control option	Research		Small		Typical		Total	
	Mg	ton	Mg	ton	Mg	ton	Mg	ton
1	0.027	0.03	0.22	0.25	7.59	8.36	7.84	8.64
2	0.009	0.011	0.080	0.090	2.64	2.97	2.73	3.07
3	0.003	0.003	0.025	0.025	0.77	0.88	0.80	0.91
4A	0.002	0.002	0.01	0.01	0.33	0.44	0.34	0.45
4B	0.002	0.002	0.01	0.01	0.33	0.44	0.34	0.45

[a] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[b] Metric and English units may not convert exactly due to independent rounding.

TABLE F-5. AMOUNT AND VALUE OR CHARGE OF RECOVERED SOLVENTS FOR MODEL SOLVENT STORAGE TANKS

Storage tank control option	Control device type	Uncontrolled emissions, Mg/yr (tons/yr)	Overall efficiency, %	VOC emissions controlled, Mg/yr (ton/yr)	Distillation efficiency, %[a]	Total VOC recovered, Mg/yr (ton/yr)[b]	Recovered value, \$/Mg (\$/ton)[c]	Total value of recovered solvent, \$/yr	Disposal charge, \$/drum	No. drums to be disposed per year	H_2O & VOC disposal charge, \$/Mg (\$/ton)[b]	VOC & H_2O to be disposed, Mg/yr (ton/yr)[c]	Total disposal charge, \$/yr
2 Typical	Conservation vent	0.69 (0.76)	65	0.45 (0.49)	N/A	0.45 (0.49)	1,279[e] (1,160)[e]	576	N/A	N/A	N/A	N/A	N/A
Small	Conservation vent	0.05 (0.05)	65	0.03 (0.033)	N/A	0.03 (0.033)	1,279[e] (1,160)[e]	38	N/A	N/A	N/A	N/A	N/A
Research	Conservation vent	0.03 (0.03)	65	0.018 (0.02)	N/A	0.020 (0.022)	1,279[e] (1,160)[e]	23	N/A	N/A	N/A	N/A	N/A
3 Typical	Pressure relief valve[d]	0.69 (0.76)	90	0.62 (0.68)	N/A	0.62 (0.68)	1,279[e] (1,160)[e]	793	N/A	N/A	N/A	N/A	N/A
Small	Pressure relief valve[d]	0.045 (0.05)	90	0.041 (0.045)	N/A	0.041 (0.045)	1,279[e] (1,160)[e]	52	N/A	N/A	N/A	N/A	N/A
Research	Pressure relief valve[d]	0.027 (0.03)	90	0.024 (0.027)	N/A	0.024 (0.027)	1,279[e] (1,160)[e]	31	N/A	N/A	N/A	N/A	N/A
4A Typical	C.A.-Fi[f]	0.69 (0.76)	95	0.66 (0.72)	N/A	N/A	N/A	N/A	71	9.5	N/A	N/A	674
Small	C.A.-Fi[f]	0.045 (0.05)	95	0.043 (0.048)	N/A	N/A	N/A	N/A	71	1.61	N/A	N/A	114
Research	C.A.-Fi[f]	0.027 (0.03)	95	0.026 (0.028)	N/A	N/A	N/A	N/A	71	0.97	N/A	N/A	69
4B Typical	C.A.-Fi + Fl	0.69 (0.76)	95	0.66 (0.72)	90	0.594 (0.648)	764[g] (693)[g]	454	N/A	N/A	N/A	N/A	N/A
Small	C.A.-Fi	0.45 (0.05)	95	0.043 (0.048)	N/A	N/A	764[g] (693)[g]	N/A	N/A	N/A	25	0.11	3
Research	C.A.-Fi	0.027 (0.03)	95	0.026 (0.029)	N/A	N/A	764[g] (693)[g]	N/A	N/A	N/A	25	0.06	2

(continued)

TABLE F-5. (continued)

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[a] Distillation systems can be designed only for the typical model coating operation; therefore, only emissions from the typical storage tank controlled in common with the coating operation can be recovered (control option 4B).

[b] The disposal charge of \$26.4/m^3 (10¢/gal) of the solvent and water mixture was converted to \$/Mg (\$/ton) assuming an equal mixture (by volume), a water density of 996 kg/m^3 (8.3 lb/gal), and a solvent mix density of 900 kg/m^3 (7.5 lb/gal).

[c] For the carbon adsorption system, the solvent is recovered in an equal amount of water (by volume). The density of the solvent mix is 900 kg/m^3 (7.5 lb/gal), and the density of water is 996 kg/m^3 (8.3 lb/gal). Therefore, the Mg/yr (tons/yr) of recovered solvent is multiplied by 211 percent for the Mg/yr (tons/yr) of solvent plus water.

[d] Credit given for solvent "saved" from escaping into the atmosphere.

[e] From the average value of virgin solvent in \$/m^3 (\$/gal), based on industry data and control device vendor data. The values of \$1,148/m^3 (\$4.35/gal) and 900 kg/m^3 (7.5 lb/gal) were used for the solvents.

[f] Disposable-canister carbon adsorber.

[g] From the average value of recovered solvents in \$/m^3 (\$/gal), based on industry data and control device vendor data. The values of \$686/m^3 (\$2.60/gal) and 900 kg/m^3 (7.5 lb/gal) were used for the solvent mixture.

Abbreviations used in the table:

C.A.-Fi = Fixed-bed carbon adsorber.
C.A.-Fi + Fl = Fixed-bed and fluidized-bed carbon adsorbers.
N/A = Not applicable.

TABLE F-6. CAPITAL COSTS OF CONSERVATION VENTS FOR CONTROL OF SOLVENT STORAGE TANKS[a]

Cost item		Line size	
	Research	Small	Typical
1. Valves[b]			
• Price per 2-in. valve = $313 (1983 $)			
• No. of valves	5	3	3
• Cost, $	1,565	939	939
• Purchased equipment, $: (1.18)(cost)	1,847	1,108	1,108
• Total installed cost, $: (1.50) x (purchased equipment)	2,770	1,662	1,662

[a] Conservation vent set at 17.2 kPa (2.5 psig).
[b] Cast aluminum body and 316 stainless steel internals.

TABLE F-7. ANNUALIZED COSTS OF CONSERVATION VENTS FOR CONTROL OF SOLVENT STORAGE TANKS[a]

Cost item	Line size		
	Research	Small	Typical
1. Labor	0	0	0
2. Utilities	0	0	0
3. Maintenance	0	0	0
4. Indirect costs			
• Overhead, $	0	0	0
• Capital charge[b], $	562	337	337
5. TOTAL ANNUALIZED COSTS, $	562	337	337
6. Credit from solvent "saved," $[c]	23	38	576
7. Net, $	539	299	-239

[a] Conservation vent set at 17.2 kPa (2.5 psig).

[b] 20.275 percent of total installed capital cost.

[c] See Table F-5.

TABLE F-8. INSTALLED COSTS OF ATMOSPHERIC TANKS AND PRESSURE TANKS[1,a]

Tank volume, m^3 (gal)	Atmospheric tank (API 12F) cost, $[b]	Pressure tank (ASME code) cost, $[c]
14.3 (3,780)	9,144	8,600
15.9 (4,200)	9,843	9,100
23.8 (6,300)	12,229	10,200
31.8 (8,400)	15,179	13,500
33.4 (8,820)	14,921	14,300
39.7 (10,500)	16,385	16,000
47.7 (12,600)	18,715	18,500
63.6 (16,800)	22,126	23,700
79.5 (21,000)	26,660	28,600

[a] All costs are for installed tanks, ready for piping, and have an accuracy of ±25 percent.

[b] American Petroleum Institute design tanks, supported by sandfilled ring-type foundations.

[c] American Society of Mechanical Engineers code tank, with a maximum working pressure in excess of 103 kPa (15 psi) and supported by two saddles.

TABLE F-8a. CAPITAL COSTS OF CARBON ADSORBER[2] FOR CONTROL OF SOLVENT STORAGE TANKS--SEPARATE[2]

Cost item	Line size		
	Research	Small	Typical
1. Ductwork from storage tanks to disposable-canister carbon adsorber			
• Pipe diameter, cm (in.)	10 (4)	10 (4)	10 (4)
• Length, m (ft)	91 (300)	55 (180)	55 (180)
• No.			
--Flanges	80	48	48
--Bolts and gaskets (sets of 4)	160	96	96
--Elbows	15	9	5
--Dampers	5	3	3
--Pipe supports (6-m[20-ft] high)	15	9	9
• Cost, $			
--Pipe	2,340	1,404	1,404
--Flanges	1,840	1,104	1,104
--Bolts and gaskets	1,380	828	828
--Elbows	175	105	105
--Dampers (x 1.44 for 1983 $) (x 1.18 for purchased equipment)	4,720	2,832	2,832
--Pipe supports	2,115	1,269	1,269
--Total	12,570	7,542	7,542
• Manhours to install, h			
--Pipe	36	21.6	21.6
--Flanges	152	91.2	91.2
--Bolts and gaskets	272	163.2	163.2
--Elbows	57	34.2	34.2
--Dampers	6	3.6	3.6
--Pipe supports	9.4	5.6	5.6
--Total manhours	532.4	319.4	319.4
--Labor cost @ $19.60/h, $	10,435	6,260	6,260
• Total direct costs, $	23,005	13,802	13,802
• Overhead @ $11.76/h, $	6,261	3,756	3,756
• Administration, 10% of direct costs, $	2,300	1,380	1,380
• Taxes, 5% of material costs, $	628	377	377
• Total indirect costs, $	9,189	5,513	5,513
• Total installed cost, $	32,194	19,315	19,315
2. Total installed cost, $[a]	32,194	19,315	19,315

[a] The disposable-canister carbon adsorber is considered an annualized cost.

TABLE F-8b. CARBON ADSORBER ANNUALIZED COSTS FOR CONTROL OF SOLVENT STORAGE TANKS--SEPARATE

	Line size		
	Research	Small	Typical
1. Labor	0	0	0
2. Utilities	0	0	0
3. Disposable-canister carbon adsorber			
• Emissions, Mg (ton)/yr	0.027 (0.03)	0.045 (0.05)	0.69 (0.76)
• Saturation capacity, kg (lb) VOC/ kg (lb) carbon	0.31 (0.31)	0.31 (0.31)	0.40 (0.40)
• Carbon required, kg (lb)/yr	88 (194)	147 (323)	1,727 (3,800)
• Capacity of drums, kg (lb) carbon/ drum	91 (200)	91 (200)	182 (400)
• No. of drums per year	0.97	1.61	9.5
• Total installed cost of 91 kg (200 lb) drum, $: ($1,235 ea)	1,198	1,988	N/A[b]
• Total installed cost of 182 kg (400 lb) drum, $: ($2,517 ea)	N/A	N/A	23,912
4. Maintenance	0	0	0
5. Indirect costs			
• Overhead, $	0	0	0
• Capital charges[a], $	6,527	3,916	3,916
6. TOTAL ANNUALIZED COSTS, $	7,725	5,904	27,828
7. Disposal cost, $: ($71/drum)	69	114	674
8. Net, $	7,794	6,018	28,502

[a] 20.275 percent of total installed capital costs.

[b] Not applicable.

TABLE F-8c. CAPITAL COSTS OF CARBON ADSORBER FOR CONTROL OF SOLVENT STORAGE TANKS--COMMON

Cost item	Line size		
	Research	Small	Typical
1. Ductwork from storage tanks to carbon adsorber			
• Pipe diameter, cm (in.)	10 (4)	10 (4)	10 (4)
• Length, m (ft)	122 (400)	110 (360)	110 (360)
• No.			
--Flanges	60	48	48
--Bolts and gaskets (sets of 4)	120	96	96
--Elbows	2	2	2
--Tees	4	2	2
--Dampers	5	3	3
--Pipe supports (6-m[20-ft] high)	33	30	30
• Cost, $			
--Pipe	3,122	2,810	2,810
--Flanges	1,379	1,104	1,104
--Bolts and gaskets	1,036	828	828
--Elbows	23	23	23
--Tees	102	51	51
--Dampers (x 1.44 for 1983 $) (x 1.18 for purchased equipment)	4,720	2,832	2,832
--Pipe supports	4,653	4,230	4,230
--Total	15,035	11,878	11,878
• Manhours to install, h			
--Pipe	48	43.2	43.2
--Flanges	114	91	91
--Bolts and gaskets (set of 4)	204	163	163
--Elbows	7.6	7.6	7.6
--Tees	22.8	11.4	11.4
--Dampers	6	3.6	3.6
--Pipe support	20.7	19	19
--Total manhours	423.1	338.8	338.8
--Labor cost @ $19.60/h, $	8,293	6,640	6,640
• Total direct costs, $	23,328	18,518	18,518
• Overhead @ $11.76/h, $	4,976	3,984	3,984
• Administration, 10% of direct costs, $	2,333	1,852	1,852
• Taxes, 5% of material costs, $	752	594	594
• Total indirect costs, $	8,061	6,430	6,430
• Total installed cost, $	31,389	24,948	24,948
2. Total installed cost, $[a]	31,389	24,948	24,948

[a] Carbon adsorber capital cost above that of the coating operation is negligible.

TABLE F-8d. CARBON ADSORBER ANNUALIZED COSTS FOR CONTROL OF SOLVENT STORAGE TANKS--COMMON[2]

	Line size		
	Research	Small	Typical
1. Operating Labor			
• Labor (L)[a], $	0	0	0
• Supervision, $: (0.15)(L)	0	0	0
2. Utilities			
• Steam, $: (4 kg/kg VOC)(kg VOC/yr)($17.5/$10^3$ kg) [(4 lb/lb VOC)(lb VOC/yr)($7.95/$10^3$ lb)]	2	3	48
• Electricity, $	0	0	0
• Water, $: (1 liter per min/1 kg steam)(kg steam/yr)(60 min/h)($0.033/1,000 liter) [(12 gal per min/100 lb steam)(lb steam/yr)(60 min/h)($0.124/1,000 gal)]	0	0	0
• Total, $	2	3	48
3. Raw Materials			
• Carbon replacement[b]	0	0	0
4. Maintenance			
• Labor[a]	0	0	0
• Material[b]	0	0	0
5. Indirect costs			
• Overhead, $[c]	0	0	0
• Capital chargesd, $[d]	6,364	5,058	5,058
• Total, $	6,364	5,058	5,058
6. TOTAL ANNUALIZED COSTS, $	6,366	5,061	5,106
7. Solvent disposal charge[e]	2	3	-454
8. Net, $	6,368	5,064	4,652

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[a] No additional operating labor would result from increased size of carbon adsorber.

[b] Increase above that of coating operation negligible.

[c] 80 percent of sum of operating, supervisory, and maintenance labor.

[d] 20.275 percent of total installed capital cost.

[e] Negative value indicates a credit for recovery and reuse of solvent.

TABLE F-9. INSTALLED CAPITAL AND ANNUALIZED COSTS AND ANNUALIZED COSTS PER UNIT AREA OF TAPE COATED FOR MODEL SOLVENT STORAGE TANK CONTROL OPTIONS

Cost item	Uncontrolled	Conservation vents, 17.2 kPa (2.5 psig)	Pressure relief valves, 103 kPa (15 psig)	Carbon options: Separate disposable carbon absorbers[a]	Carbon options: Common fixed-bed carbon adsorbers[b]
1. **Research**					
• Total installed capital cost					
--Storage tanks	\$12,500[b]	\$12,500	\$12,500	\$12,500	\$12,500
--Control system (including ductwork)	N/A[c]	2,800	0	32,200	31,400
--Total	\$12,500[b]	\$15,300	\$12,500	\$44,700	\$43,900
• Total annualized costs					
--Storage tanks	\$2,700	\$2,700	\$2,700	\$2,700	\$2,700
--Control system	N/A	560	0	7,700	6,400
--Credit/debit for solvent[c]	N/A	-20	-30	70	0
--Total	\$2,700	\$3,240	\$2,670	\$10,470	\$9,100
• Total annualized operating cost per unit area coated,[d] ¢/m^2 (¢/ft^2)	0.23 (0.022)	0.28 (0.026)	0.23 (0.021)	0.90 (0.084)	0.78 (0.073)
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	0.046 (0.004)	-0.003 (-0.0002)	0.67 (0.06)	0.55 (0.051)
2. **Small**					
• Total installed capital cost					
--Storage tanks	\$7,500	\$7,500	\$7,500	\$7,500	\$7,500
--Control system (including ductwork)	N/A	1,700	0	19,300	25,000
--Total	\$7,500	\$9,200	\$7,500	\$26,800	\$32,500
• Total annualized costs					
--Storage tanks	\$1,600	\$1,600	\$1,600	\$1,600	\$1,600
--Control system	N/A	340	0	5,900	5,100
--Credit/debit for solvent[c]	N/A	-40	-50	115	0
--Total	\$1,600	\$1,900	\$1,550	\$7,615	\$6,700
• Total annualized cost per unit area coated,[e] ¢/m^2 (¢/ft^2)	0.046 (0.004)	0.055 (0.005)	0.044 (0.004)	0.22 (0.02)	0.19 (0.018)
• Total annualized control system cost per unit area coated, ¢/^{2} (¢/ft^2)	N/A	0.009 (0.001)	-0.001 (-0.0001)	0.17 (0.016)	0.15 (0.014)

(continued)

TABLE F-9. (continued)

Cost item	Uncontrolled	Carbon options			
		Conservation vents, 17.2 kPa (2.5 psig)	Pressure relief valves, 103 kPa (15 psig)	Separate disposable carbon absorbers[a]	Common fixed-bed carbon adsorbers[b]
3. Typical					
• Total installed capital cost					
--Storage tanks	$28,200	$28,200	$28,200	$28,200	$28,200
--Control system (including ductwork)	N/A	1,700	0	19,300	25,000
--Total	$28,200	$29,900	$28,200	$47,500	$53,200
• Total annualized costs					
--Storage tanks	$6,100	$6,100	$6,100	$6,100	$6,100
--Control system	N/A	340	0	27,800	5,100
--Credit/debit for solvent[c]	N/A	-580	-790	670	-450
--Total	$6,100	$5,860	$5,310	$34,570	$10,750
• Total annualized operating cost per unit area coated,[f] ¢/m^2 (¢/ft^2)	0.018 (0.002)	0.017 (0.002)	0.015 (0.001)	0.1 (0.009)	0.031 (0.003)
• Total annualized control system cost per unit area coated, ¢/m^2 (¢/ft^2)	N/A	-0.0007 (-0.00006)	-0.002 (-0.0002)	0.08 (0.008)	0.013 (0.001)

N/A = Not applicable.

[a] A disposable-canister carbon adsorber controls the VOC emissions from the storage tanks only.

[b] VOC emissions from the storage tanks plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

[c] Negative values are credits for solvent recovery and reuse, based on a distillation efficiency of 90 percent. For conservation vents and pressure relief valves, credit given for solvent "saved" from escaping into the atmosphere.

[d] Total area coated annually is 11.6×10^5 m^2 (12.5×10^6 ft^2) [= (5 in.)(250 fpm)(1 ft/12 in.)(60 min/h)(2,000 h/yr)].

[e] Total area coated annually is 34.84×10^5 m^2 (37.5×10^6 ft^2) [= (5 in.)(250 fpm)(1 ft/12 in.)(60 min/h)(6,000 h/yr)].

[f] Total area coated annually is 34.84×10^5 m^2 (375.0×10^6 ft^2) [= (25 in.)(500 fpm)(1 ft/12 in.)(60 min/h)(6,000 h/yr)].

TABLE F-10. AVERAGE COST EFFECTIVENESS OF CONTROL OPTIONS WITH RESPECT TO BASELINE FOR MODEL SOLVENT STORAGE TANKS

	Control options			
Parameter	Conservation vents, 17.2 kPa (2.5 psig)	Pressure relief valves, 103 kPa (15 psig)	Separate disposable carbon absorbers[a]	Common fixed-bed carbon adsorbers[b]
1. **Research**				
• Total annualized control system cost, \$/yr[c]	540	-30	7,800	6,400
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.018 (0.02)	0.024 (0.027)	0.026 (0.028)	0.026 (0.028)
• Average cost effectiveness, \$/Mg (\$/ton)	30,000 (27,000)	-1,250 (-1,110)	300,000 (278,600)	246,200 (228,600)
2. **Small**				
• Total annualized control system cost, \$/yr[c]	300	-50	6,000	5,100
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.03 (0.033)	0.041 (0.045)	0.043 (0.048)	0.043 (0.048)
• Average cost effectiveness, \$/Mg (\$/ton)	10,000 (9,090)	-1,220 (-1,110)	139,500 (125,000)	118,600 (106,200)
3. **Typical**				
• Total annualized control system cost, \$/yr[c]	-240	-790	28,500	4,700
• Total annual VOC emission reduction, Mg/yr (tons/yr)	0.45 (0.49)	0.62 (0.68)	0.66 (0.72)	0.66 (0.72)
• Average cost effectiveness, \$/Mg (\$/ton)	-530 (490)	-1,270 (-1,160)	43,200 (39,600)	7,120 (6,530)

[a] A disposable-canister carbon adsorber controls the VOC emissions from the storage tanks only.

[b] VOC emissions from the storage tanks plus the VOC emissions from the coating operation are controlled by the same fixed-bed carbon adsorber.

[c] The costs for the common fixed-bed carbon adsorbers are for the incremental control device cost above that required for control of the coating operation alone.

TABLE F-11. INCREMENTAL COST EFFECTIVENESS OF CONTROL OPTIONS FOR MODEL SOLVENT STORAGE TANKS

Parameter	Control options			
	CV/UNC[a]	PRV/CV[b]	S-CA/PRV[c]	C-CA/PRV[d]
1. Research				
• Incremental total annualized control system cost, $/yr	540	-570	7,830	6,430[e]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.018 (0.02)	0.006 (0.007)	0.002 (0.002)	0.002 (0.002)
• Incremental cost effectiveness, $/Mg ($/ton)	30,000 (27,000)	-95,000 (-81,400)	3,915,000 (3,915,000)	3,215,000 (3,215,000)
2. Small				
• Incremental total annualized control system cost, $/yr	300	-350	6,050	5,150[e]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.03 (0.033)	0.011 (0.012)	0.002 (0.003)	0.002 (0.003)
• Incremental cost effectiveness, $/Mg ($/ton)	10,000 (9,090)	-31,800 (-29,200)	3,025,000 (2,016,700)	2,575,000 (1,717,000)
3. Typical				
• Incremental total annualized control system cost, $/yr	-240	-550	29,290	5,490[e]
• Incremental total annual VOC emission reduction, Mg/yr (tons/yr)	0.45 (0.49)	0.17 (0.19)	0.04 (0.044)	0.04 (0.044)
• Incremental cost effectiveness, $/Mg ($/ton)	-530 (-490)	-3,240 (-2,890)	732,200 (665,700)	137,200 (124,800)

[a] The incremental change for model solvent storage tanks controlled by conservation vents, CV, (17.2 kPa [2.5 psig]) compared to uncontrolled (UNC) model solvent storage tanks.

[b] The incremental change for model solvent storage tanks controlled by pressure relief valves, PRV, (103 kPa [15 psig]) compared to model solvent storage tanks controlled by conservation vents, CV.

[c] The incremental change for model solvent storage tanks controlled by a disposable canister carbon adsorber (S-CA) compared to model storage tanks controlled by pressure relief valves, PRV.

[d] The incremental change for model solvent storage tanks controlled by a fixed-bed carbon adsorber that is also controlling emissions from the coating operation (C-CA) compared to model storage tanks controlled by pressure relief valves.

[e] The costs for common fixed-bed carbon adsorbers are for the incremental control device cost above that required for control of the coating operation alone.

TABLE F-12. SOLVENT STORAGE TANK WASTEWATER DSICHARGES AND WATERBORNE VOC EMISSIONS[a,b]

Control option	Annual (typical line)[c]		Estimated 1990 National[d]	
	10^3 ℓ	10^3 gal	10^3 ℓ	10^3 gal
		Wastewater Discharges		
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4A	0	0	0	0
4B	2	0.5	22	5.5
		Waterborne VOC Emissions[e]		
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4A	0	0	0	0
4B	0.2	0.4	2.2	4.0

[a] Wastewater and waterborne VOC emissions result from the operation of fixed-bed carbon adsorbers.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Wastewater containing solvent from research and small lines is disposed as hazardous waste.

[d] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

[e] Wastewater from stripper column of distillation system contains 100 ppm VOC.

TABLE F-13. SOLVENT STORAGE TANK SOLID WASTE IMPACTS[a,b]

Control option	Annual Solid Waste Impacts					
	Research		Small		Typical	
	kg	lb	kg	lb	kg	lb
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A[c]	90	190	150	320	1,730	3,800
4B[d]	0	0	0	0	0	0

	Estimated National 1990 Solid Waste Impacts[e]	
	Mg	Ton
1	0	0
2	0	0
3	0	0
4A[c]	20	22
4B[d]	0	0

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[a] Solid waste results from the operation of fixed-bed and fluidized-bed carbon adsorbers.

[b] Metric and English units may not convert exactly due to independent rounding.

[c] Disposable canister carbon adsorber.

[d] Negligible.

[e] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

TABLE F-14. SOLVENT STORAGE TANK ENERGY REQUIREMENTS[a]

Control option	Annual steam and total energy requirements[b]					
	Research		Small		Typical	
	GJ	10^6 Btu	GJ	10^6 Btu	GJ	10^6 Btu
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A[c]	0	0	0	0	0	0
4B[d]	0.26	0.25	0.44	0.42	6.70	6.35

Estimated National 1990 Energy Demand[b,c]

	GJ	10^6 Btu
1	0	0
2	0	0
3	0	0
4A	0	0
4B	76	72

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[a] Metric and English units may not convert exactly due to independent rounding.

[b] There are no electrical energy and natural gas requirements for the storage tank control options.

[c] Based on the equivalent of 1 research line, 5 small lines, and 11 typical sized lines.

TABLE F-15. SUMMARY OF ANNUAL SECONDARY POLLUTANT EMISSIONS FROM STEAM GENERATION FOR CONTROL OF SOLVENT STORAGE TANKS

Control option	Emission levels[a] PM[b] kg	lb	SO_x kg	lb	NO_x kg	lb
			Research			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A	0	0	0	0	0	0
4B	0.017	0.038	0.22	0.49	0.05	0.12
			Small			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A	0	0	0	0	0	0
4B	0.03	0.06	0.4	0.8	0.1	0.2
			Typical			
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4A	0	0	0	0	0	0
4B	0.4	1.0	5	12	1.4	3

[a] Metric and English units may not convert exactly due to independent rounding.

[b] PM = particulate matter.

REFERENCES FOR APPENDIX F

1. Letter and attachments from Dabney, O., Jr., D. A. Associates, to Berry, J., EPA:CPB. January 15, 1985. Cost of atmospheric tanks and pressure vessels.

2. Memo and attachments from Beall, C., MRI, to Johnson, W., EPA:CPB. Revised final tabular cost. March 15, 1985. Costs for model storage tanks, model mix rooms, and model coating operations for the magnetic tape manufacturing industry.